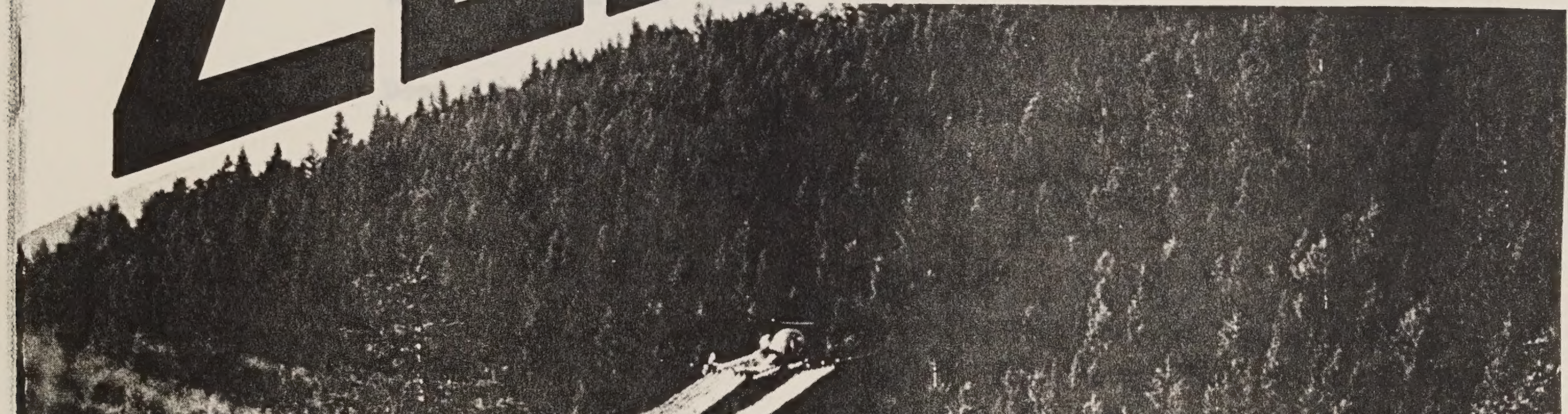
THE 1967 BIG SMOKY SPRUCE BUDWORM ZECTRAN PROJECT



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE - INTERMOUNTAIN REGION

WOOD · WATER · FORAGE · WILDLIFE · RECREATION
FOREST SERVICE
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DEPARTMENT OF AGRICULTURE

Regional Forester
Forest Service
Federal Office Building
324 25th Street
Ogden, Utah 84401

5240

March 5, 1969

Art Matilla, Engineer
U. S. Forest Service
Missoula Equip. Dev. Center
Missoula, Montana 59801

Dear Sir:

Enclosed is our report of the Spruce Budworm Spray Project conducted on the Sawtooth National Forest in July 1967.

We regret the delay in publication of the report but believe the information it contains will still be of interest to you.

Sincerely yours,

Marlin C. Galbraith

MARLIN C. GALBRAITH
Assistant Regional Forester
Division of Timber Management

Enclosure

THE 1967 BIG SMOKY SPRUCE BUDWORM
ZECTRAN PROJECT

An Administrative Study conducted by the
SAWTOOTH NATIONAL FOREST
Intermountain Region

With the help of:

INSECTICIDE EVALUATION PROJECT
Pacfic Southwest Forest and Range Experiment Station

and the

MISSOULA EQUIPMENT DEVELOPMENT CENTER
Northern Region

of the U. S. FOREST SERVICE, DEPARTMENT OF AGRICULTURE

Cooperating were the following agencies:

DENVER WILDLIFE RESEARCH LABORATORY
Bureau of Sport Fisheries and Wildlife

FIRE-WEATHER MOBILE UNIT, BOISE
Weather Bureau, Western Region

DEPARTMENT OF FISH AND GAME
State of Idaho

STANFORD RESEARCH INSTITUTE

Report prepared by:

SHAG TAYNTON
Project Leader

FOREWORD

The 1967 Big Smoky Spruce Budworm Zectran Project was a further step taken by the Forest Service in finding a substitute insecticide for DDT. Since 1964, the U. S. Forest Service Pacific Southwest Forest and Range Experiment Station has conducted an Insecticide Evaluation Project under the direction of Dr. Arthur Moore who has been testing in laboratory and field the carbamate insecticide Zectran. The work at Big Smoky advanced technology in aerial spraying equipment and methods of application as well as furthering the knowledge of the efficiency of the insecticide itself.

Unfortunately the weather affected insect development to such an extent that the spray test was reduced from 64,000 acres to about 2,000 acres. In spite of the adverse weather and failure of the insect population to develop, this project pointed the way for the final phase of development of a substitute insecticide for use against the spruce budworm.

This report by the project leader is a collection of the information reported by the several cooperators and project overhead, highlighting the major jobs, and accomplishments of each.

An expression of thanks is extended to all those who cooperated and contributed their skills and aid to help make this a successful project.

CONTENTS

BACKGROUND

The spruce budworm (Choristoneura sp.) is one of the most destructive forest insect pests in America. In Region 4 of the Forest Service alone, there were over 992,000 acres infested as indicated by the 1966 annual aerial survey.

The spruce budworm first became a serious problem in the Region in the early 1950's. From 1954 to 1957, four spruce budworm control projects were conducted against the insect. Almost 3.2 million acres were sprayed with DDT during these four years, reducing the budworm population to a tolerable level. Gradually, the infestation built back again, largely on previously uninfested areas, and in 1963 a second series of control projects was started. In 1963, 200,000 acres were treated with DDT; and 1964, 525,000 acres were treated also with DDT. During these years, pilot tests of other insecticides (Sevin in 1963 and Cygon in 1964) were conducted in the search for a nonpersistent insecticide that would be effective against the spruce budworm. In 1965, a pilot test of malathion was conducted on 8,000 acres. This nonpersistent insecticide proved sufficiently promising to warrant using it to suppress the insect where timber losses are likely to be heavy, but not to effect full-scale control.

There has been much controversy in the past few years over the use of DDT and other persistent insecticides. Objections have been raised by wildlife and health groups because the DDT persists for many years. They point to increasing amounts of the insecticide found worldwide in almost all life and object to any further use of it.

The Forest Service has been testing insecticides for several years in an effort to find a nonpersistent substitute for DDT, one which is relatively harmless to warmblooded animals and fish, but at the same time is effective, economical, and easy to apply over large areas.

In 1964, the Insecticide Evaluation Project at Berkeley screened some candidate insecticides at Salmon, Idaho. Zectran showed much promise. In 1965 the Insecticide Evaluation Project conducted some tests with this carbamate insecticide in Region 1. Their tests indicated the insecticide was promising and ready for large scale pilot tests. Further laboratory work with different formulations were tested in the winter season. Then in 1966 two field tests, using three types of aircraft in Region 1 and Region 4, proved to be highly successful. During the field tests, an intensive surveillance program was conducted on both aquatic and terrestrial forms of life. Zectran spraying proved of little or no hazard to other forms of life or to the environment.

During the 1966 Zectran tests, fluorescent particles were mixed in the spray. After spraying, the target insects were examined to see what size drop was actually getting to the insects. It was found that the smaller drops of the insecticide were much more effective than larger drops. The larger the drops, the more insecticide was wasted. One

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wasteful 400-micron drop contains enough insecticide to make 512 effective 50-micron drops. This new knowledge presented two major problems in aerial application techniques.

The first problem was how to insure that all drops are the small effective size. On past aerial spray projects drops range from the smallest sizes to 300 or 400 microns in size with the average size 150 to 300 microns.

The second problem was how to determine where the spray will go after it is released from the aircraft. In past projects, using the larger, heavier drops, we knew that most fell relatively close to where they were released. However, the small drops, like smoke particles, are more subject to the atmospheric conditions which effect the transport and diffusion of small particles.

In 1966 scientists from the Insecticide Evaluation Project were able to follow the spray drift on the test area with a laser beam and radar (the lidar gun). From these and other tests with smoke, the scientists learned that it is possible to predict the atmospheric conditions (wind and thermal currents) in each small drainage. The addition of small insecticide droplets to this air movement at the time of day when atmospheric conditions are right will provide the transport needed to reach the budworm on any tree throughout the drainage.

PLANNING

On November 2, 1966, a planning meeting to discuss the size and scope of the proposed 1967 Zectran test was held in the Regional Office. Personnel participating were from the Insecticide Evaluation Project (IEP), Berkeley, California; the Missoula Equipment Development Center (MEDC), Missoula, Montana; the Sawtooth National Forest; and the Regional Office Divisions of Timber Management, Fire Control and State and Private Forestry, Operation, and Wildlife.

An administrative study plan was prepared in the Division of Timber Management. This study plan spelled out the general methods to be used in applying the insecticide and in determining the effects.

On January 19 and 20 and on February 6, 1967, meetings were held at Berkeley and Las Vegas respectively between project overhead and personnel from IEP and the Missoula Equipment Development Center in order to firm up plans and review progress for the 1967 Smoky Spruce Budworm Project. Formal plans based on these discussions were prepared as follows:

Administrative Study Plan	January 16, 1967
Multiple Use Plan	January 23, 1967
I&E Plan	January 30, 1967
Operational Plan, including Surveillance	May 15, 1967
Entomological Plan	May 16, 1967
Safety Plan	April 4, 1967
Communications Plan	May 1967

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[illegible] Project. [illegible] plans [illegible] on these discussions [illegible]

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Organization

The project was organized as an administrative study to test, on control project scale, new techniques and equipment being developed by the Insecticide Evaluation Project team at Berkeley. Much preliminary field testing and proving of both the equipment and the techniques were planned by Dr. Moore's team prior to the actual spray project. It was intended, as part of the IEP preliminary work, to train control project personnel in the use of the new equipment and techniques. Dr. Moore directed the preliminary experimenting and equipment testing during June and July. The Sawtooth National Forest project team served as trainees in the new methods and as a service organization for IEP.

If the project had not been reduced to a small 2,300-acre 1-day test, the Sawtooth team would have directed the spraying on the bulk of the area after the first day or two of training by the IEP team.

In late November, 1966, Shag Taynton was designated project leader, Harold Flake, entomologist, and Pete Walker was named assistant project leader and information officer. These men formed the nucleus of the organization and did all the preliminary project planning and preparation. The first crews started arriving about June 5. The peak employment was reached about the last week in June. The chart, page 4, shows the full organization and the personnel in the more important jobs.

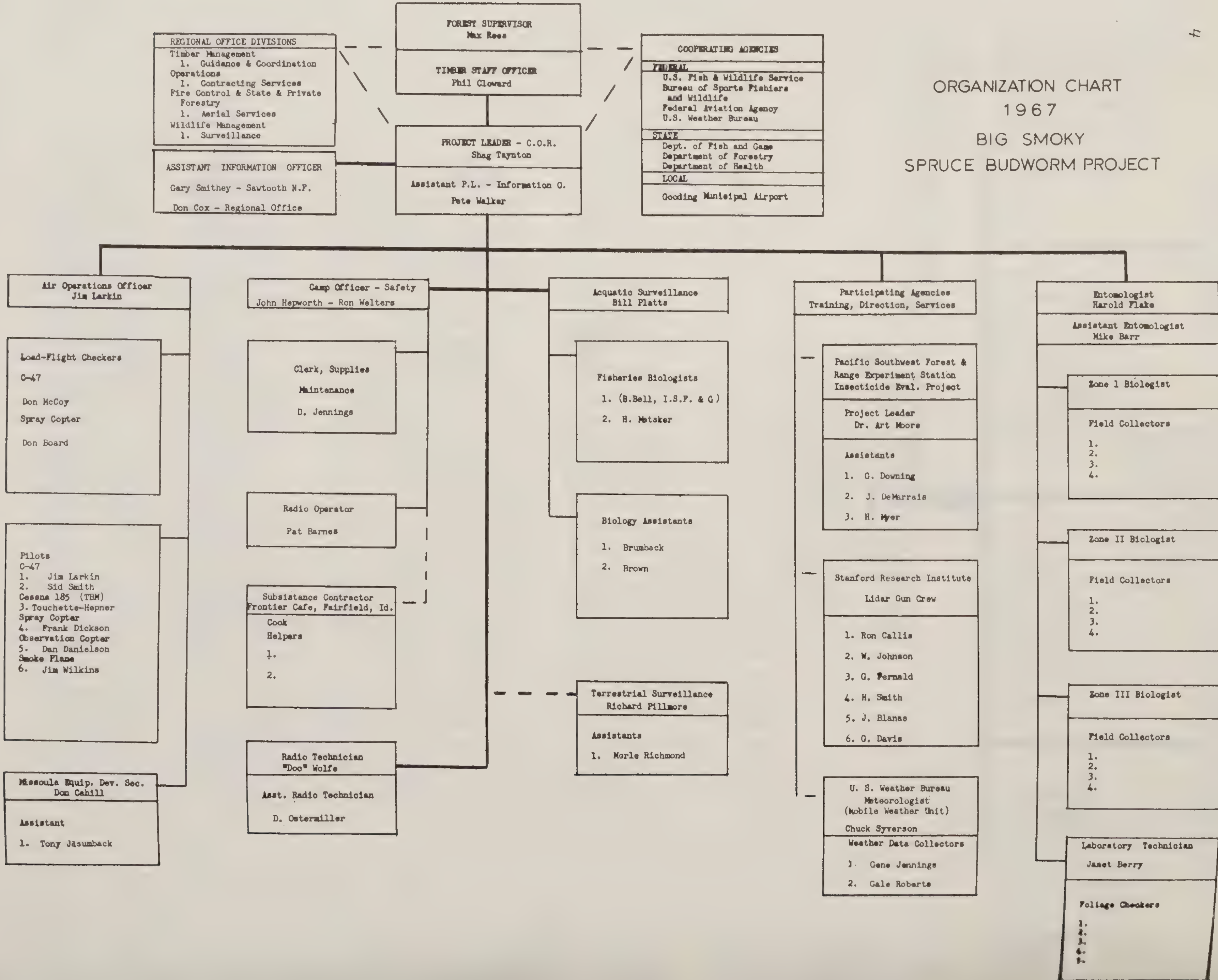
The organization, as designed, functioned rather well as a team for this project. The various cooperators were able to carry out their responsibilities with no friction or trouble between the various cooperators or project people. Following are some minor changes which might make this and other projects function better:

1. The assistant project leader position was filled as a part-time position from the Sawtooth National Forest. However, because the assistant project leader had three other major activities, he could only devote part time to the Zectran Project. His other activities also suffered. A full-time position was needed to enable the project leader to devote more time to the actual field test and spray operations.

2. The assistant project leader, in addition to his duties outside the project also served as information officer with two part-time assistant information officers. Future projects should have one information officer of high caliber who can devote full time to project work.

3. The entomological organization was excessive for the size of the project that was planned. From experience and observation, on other aerial spray projects, (and observing the amount of work required of each crewman on this project) the planned work could have been performed with a considerably smaller crew. Of course, when the size of the project was drastically reduced, the actual workload was reduced which compounded overmanning problem.

ORGANIZATION CHART
1967
BIG SMOKY
SPRUCE BUDWORM PROJECT



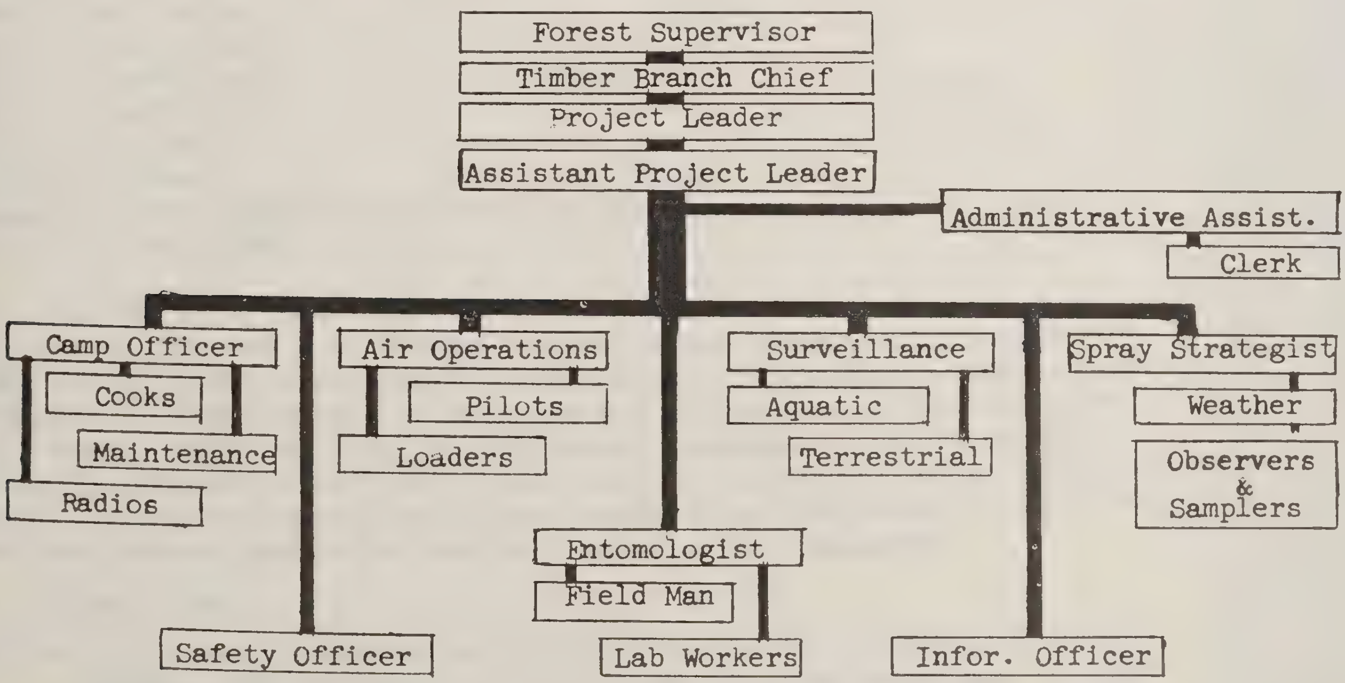
4. The entomological crew could have functioned more efficiently if the lab had been established at the camp instead of at Gooding 60 miles away. This would have eliminated almost twice daily trips by the project entomologist and would have enabled him to spend that time in the field with his crew.

5. Using the new techniques of spraying being developed by Dr. Moore requires a better knowledge of weather, spray behavior, and aircraft use. In fighting large fires we need fire behavior officers and fire bosses who have had special fire generalship training; in spraying we need specially trained men also.

   A specialist is needed in the project spray organization whom might be called a "Spray Strategist." His job would be to direct the actual spray application. He would have the weather observers report directly to him but would not be responsible for any other operational details. He would decide how much, when, and where to apply the spray. He would lay out the days spraying runs and watch the spraying from aircraft or ground locations and direct the work as needed.

   Needless to say this man would have special training and experience to prepare him for this type spraying. His full-time job ought to be in a related field with duties which allow him to be detailed to spray projects in whichever Region they occur. There is a real need for three or four of these specialists in the Forest Service.

6. If another similar project were being organized the organization should be as follows:



The entomological work would have been much more efficiently [illegible] if the lab had been established at the very location of [illegible] Dr. [illegible] instead of [illegible] 60 miles away. [illegible] would have eliminated almost twice daily trips to the project area, and would have enabled him to spend that time in the field with his crew.

Using the new techniques of spray [illegible] developed by Dr. Moore requires [illegible] knowledge of weather, spray behavior, and aircraft use. In fighting large fires, fire behavior [illegible] and fire [illegible] have special fire [illegible] training. [illegible] spraying we need specially trained [illegible].

A specialist [illegible] on the project [illegible] would [illegible] "[illegible] "[illegible]." His job would be to direct [illegible] spray [illegible] He would know the weather [illegible] directly to him [illegible] pronounce [illegible] spray [illegible] would decide how much, when and where to apply the spray. He would try out [illegible] and watch the spraying from aircraft [illegible] ground [illegible] as needed.

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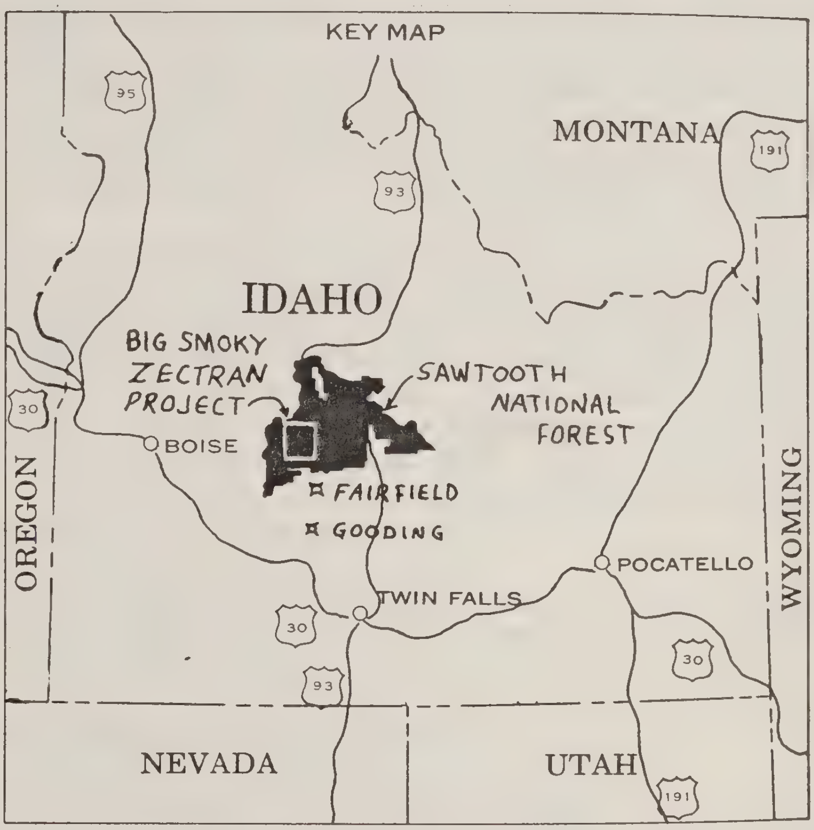
Project Area

The 1967 Big Smoky Spruce Budworm Project area was on the Sawtooth National Forest about 30 miles west of Sun Valley, Idaho, at the confluence of the South Fork of the Boise River with Big Smoky Creek. There were over 100,000 acres in this large basin area of the upper South Fork of the Boise River that were infested with the spruce budworm.



There are numerous live streams draining steep, rugged mountains. The south facing slopes are mostly open sagebrush and grass while the north slopes are heavily timbered with mixed conifers. The South Fork of the Boise River, the largest stream, is 20 to 50 feet wide in the project area.

Access into the areas was afforded by several fair to good forest roads. Trails lead up most of the larger drainages. However, the South Fork, swollen by spring runoff, presented a formidable barrier for travel into the infested forest to the south during June.

About 60,000 to 70,000 acres were originally scheduled for spraying. However, a long wet cold spring apparently was largely responsible for reducing the budworm numbers to a very light infestation. Once sampling confirmed the low numbers, a decision was made to spray only that area which would adequately test the new spray techniques and determine Zectran's effects on terrestrial and aquatic organisms. About 2,000 acres in lower Salt Creek and Fleck summit areas were found to have the heaviest budworm population and were selected for spraying.

The Project Plan

Originally it was planned to spray with 0.03 lbs of Zectran in one-half pint of Dowanol TPM per acre. It was planned to take advantage of atmospheric transport and diffusion by using a spray consisting of a fine mist with droplets less than 50 microns in size.

Both the volume of spray and the droplet size were untried concepts in aerial spraying. As such, there were many questions to be answered before such a spray project could be conducted with confidence. Equipment had to be developed which would produce the small droplets. Atmospheric transport and diffusion over mountainous forest conditions had to be investigated. The spray equipment development was assigned to the Missoula Equipment Development Center for completion by early June. Investigation of atmospheric transport and diffusion of spray was undertaken by Dr. Moore. During the month of June tests with smoke released from aircraft and from ground locations, and simulated spray runs using the spray solvent, were to be made and checked with the use of the lidar gun.

Aquatic and terrestrial surveillance was planned to supplement lab and field work of previous years. The aquatic surveillance was to be conducted by our Sawtooth National Forest crew under the direction of a fisheries biologist detailed from the Payette National Forest. The terrestrial surveillance was to be carried out by biologists from the Denver Wildlife Research Center of the Fish and Wildlife Service.

Extensive sampling of budworm, other insects, foliage, air, and soil was planned to find out where the insecticide was finally deposited. Many budworm development, population, and mortaility plots were to be established throughout the spray area to determine the budworm population both before and after spraying. Plans were also made to rear in a laboratory, some of the insects to determine what effects the spray might have on the natural parasites. This work was to be under direction of an Intermountain Region entomologist in cooperation with the entomologists from Berkeley.

These plans required establishing a camp and service organization for 60 men at Big Smoky, a laboratory at Gooding, and an air operations headquarters at the Gooding airport.

<u>Responsibilities of Participating Agencies</u>

1. Sawtooth National Forest, Forest Service, Region 4: (1) To serve as a service organization to provide men, tools, equipment, and subsistence to all participating agencies in developing Zectran spray techniques. (2) To have R-4 personnel serve as trainees in the new spray techniques and concepts. (3) To provide entomological services. (4) To provide equatic surveillance services.

2. Insecticide Evaluation Project, Pacific Southwest Forest and Range Experiment Station, Forest Service: (1) Develop spray techniques using atmospheric transport and diffusion. (2) Train R-4 personnel in new spray techniques. (3) Test effectiveness of Zectran using new techniques. (4) Test air samplers as aid in spray deposit assessment.

3. Missoula Equipment Development Center, Region 1, Forest Service: (1) To provide, install, test, and maintain spray equipment on three types of aircraft.

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1. [illegible] National Forest, Forest Service, Region 4: (1) [illegible] organization to provide men, tools, equipment, and assistance to all participants, [illegible] spray techniques. (2) [illegible] personal service [illegible] the [illegible] spray treatment [illegible]. (3) To provide [illegible] logical services. (4) To [illegible] surveillance [illegible]

2. Intermountain Experiment [illegible] Forest Service: (1) Develop [illegible] atmospheric [illegible] (2) [illegible] spray [illegible] (3) Test effectiveness of [illegible] Test [illegible] spray [illegible]

[illegible]

[illegible] Center, Region 1, Forest Service.

[illegible], and [illegible]

4. Stanford Research Institute: (1) Provide and operate lidar equipment capable of tracing spray for up to 30 minutes after it had been released from the aircraft.

5. U. S. Weather Bureau: (1) To provide mobile weather unit and meteorologist with capabilities of analyzing the weather both locally and Regionwide.

6. Denver Wildlife Research Center, Bureau of Sports Fisheries and Wildlife: (1) To provide terrestrial surveillance services.

7. State of Idaho Fish and Game Department: Participate in planning and carrying out aquatic surveillance.

PUBLIC INFORMATION

Because of the new roads being blazed in forest insecticide spraying, this project generated international interest from insecticide researchers and users both in Government and industry. The project was also of interest to Federal, State, and local government officials. There was almost a steady stream of high Government and industry visitors to the project. In addition to the technical interest generated, the project was of general interest to the local public.

The 1967 Big Smoky Spruce Budworm Project developed Nationwide and even international interest. Many visitors came to the project to watch the lidar work and the spraying with the use of the atmospheric transport and diffusion techniques. A field trip to the project was arranged to inform State of Idaho officials of the Idaho forest pest conditions, including not only the Spruce Budworm Zectran Project, but the large bark beetle projects on the Targhee and Teton National Forests.

Front row: A. M. Rivas, D. F. Engelking, E. Wohletz, Joe Williams, Jack Gillette, Ted Hoff, Joe Pechanec. Second row: Marlin Galbraith, Max Rees, Vern Guernsey, Bob Hayes, Bob Lorimer, Wilhelm Becket. Third row: Fred Humphreys, Joel Frykman, Jim Simpson, Alex Smith, Art Roberts, Floyd Iverson, Gary Smithey.

In carrying out the I&E plan many contacts were made, news media were advised, and a number of formal show-me trips were arranged. This resulted in very favorable publicity and public acceptance.

The information and education job for the general public was adequately handled. The big I&E job on this unique project was with the visitors interested in the technical details.

As already mentioned, a full-time I&E officer should have been assigned to this project. The caliber and number of visitors attracted to the project necessitated that the I&E officer be technically knowledgeable in spray techniques and aircraft spray equipment as well as adept at handling and caring for visitors. In future projects of this type the full-time I&E man should be able to adequately explain the intricacies of the equipment, methods and materials used, and thus relieve the project overhead of this added impact. Lists of: 1. contacts; 2. news coverage; 3. "show-me" trips; 4. materials prepared; and 5. special visitors are included in the appendix.

Table display was one of several information devices prepared for the 1967 Zectran project use. Other devices included three brochures, a film, a slide lecture, and a television interview.

OPERATIONAL DETAILS

Budget and Finance

In October of 1966, a project request was submitted by the Sawtooth National Forest to the Washington Office requesting an estimated $112,000. Subsequent estimated, based on more detailed plans were submitted periodically, and additional financing was granted as needed. Direct project expenditures paid for by the Sawtooth National Forest amounted to about $165,000.

Contributed to the project from other funds (mostly salaries) was an additional $31,800. Other agencies who cooperated in the project work spent an additional $89,700 for a total estimated project cost of around $286,660. This represents a total cost of $124.36 per acre sprayed, an alarming figure. There are several reasons why the figure is so high compared with reported figures of $1 to $3 per acre for other aerial spray projects.

The normal aerial spray project reports do not include any of the contributed costs ($31,800) or other agency expenditures ($89,700). Excluding these two figures the project cost per acre becomes $71.65. The project was planned for 64,000 acres rather than the 2,305 acres which were actually sprayed. The decision to reduce the project to 2,305 acres came after men, equipment, and materials had been procured for the larger project. Dividing by 64,000 acres the per acre cost becomes about $2.60 per acre or comparable with DDT projects.

Camp expenditures added about $38,000 to the project costs. Most projects get by without camp construction costs by utilizing commercial or existing facilities and hiring local employees. The Big Smoky project area was just too far from a population area to make this practical. Associated camp costs for normal projects would be less than $5,000.

The estimate for cost/acre for this project if reported on the same basis as past projects would be in the neighborhood of $2/acre. We should expect future control projects to be close to this figure. Large projects may cost far less per acre.

A complete table of expenditure is listed in the appendix.

The project financial functions were handled by regular Sawtooth National Forest personnel along with their normal duties. This resulted in an overload of work for some of the office personnel and noticeable errors in recordkeeping, especially in automatic data processing coding. The ADP coding was rather complex in order to provide rather detailed costs. An analysis of cost needs and alternative accounting systems should determine the best way to gather and record cost data. Future projects of this size should have an Administrative Assistant detailed directly to the project who can devote all his time to project matters. He should be involved directly in the planning phases as well as final analysis of the cost data.

Camp and Subsistance

As soon as the Zectran Administrative Study at Big Smoky was approved, the Sawtooth National Forest personnel began planning and building the camp. Considerable planning and work was done in the fall at a site on the west side of Paradise Creek. However, the wet spring revealed there was insufficient drainage on the original site so it was abandoned and the camp was built on the east side of the Creek. Due to the cold wet spring and record snowfall, construction was difficult and costly. In spite of the adverse conditions, camp was functioning by June 6, only

six days later than requested. By the 15th of June, the camp was virtually complete and quite comfortable. The camp was built to a higher standard than would have been required for project use alone because long-range forest plans were to convert the facilities into a permanent forest project work center. As a result, the camp costs for this project appear to be excessive.

Project headquarters and base camp facilities had to be provided for up to 60 men for a period of two months. The area was cleared and leveled, permanent sewer and water systems laid, shower and toilet facilities built and kitchen, dining, and sleeping trailers and canvas quonsets erected during April and May for occupancy by June 5.

Permanent sewer, water, and washhouse facilities were constructed. Grading, clearing, and leveling of space for six quonsets, four trailers, messhall, shower house, recreation area, and parking was done to a high standard. The messhall and kitchen were constructed by placing three trailers together with the largest serving as the dining room and two small ones serving as kitchen and serving area respectively.

A contract was let to the Frontier Cafe, Fairfield, to provide cooks, labor, food, and serve meals at $2.00 per meal. This arrangement was satisfactory. Meals were quite good and portions were adequate. Pastries were excellent. Approximately 4,000 meals were served.

Communications

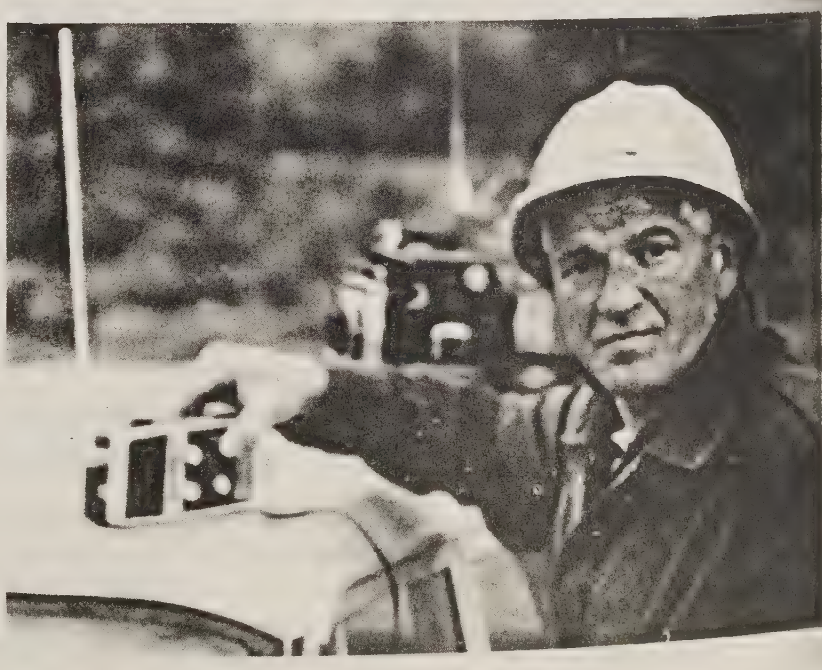
Adequate communications networks were planned for installation the last two weeks of May. All installations were not completed, however, until about the third week in June. The communications plan called for a radio technician on the job from June 19 until spraying was completed. This service was not provided until much later; but when the technician finally arrived, communications difficulties were alleviated quickly and efficiently.

Single side band radios were installed at the Big Smoky Camp, the Fairfield Ranger's Office, and at the Air Operations Office at Gooding. In addition the meteorologist had an SSB set on the same frequency in his mobile unit. The SSB set was invaluable. Without these radios the project communications would have been seriously handicapped. The sets were virtually trouble free and worked well any time of the day or night.

It is strongly recommended, however, that the sets placed at town locations be provided with "automatic telephone patches." These are devices that allow a hook-up between the radio network and the commercial telephone system. They cost under $20 but if provided on the 1967 project could have saved many times that much money in time saved and transportation costs reduced.

Another feature of the communications system which proved valuable was the two small transistorized portables which were used in the field. The radios were on the standard aircraft frequencies of 122.8, 122.9, and 123.0. Base stations with the same frequencies were installed at the camp and at the Air Operations Trailer at Gooding. This network enabled full communications with all aircraft from any ground location as well as from any other aircraft. All smoke tests, simulated spray runs, and spraying were controlled by the use of this network. A similar network is a must for any future aerial spray project.

Ground communications consisted of a base set at camp, a portable repeater located on Paradise Ridge, and a number of portable hand sets. The base set repeater and four heavy portables were provided by Insecticide Evaluation Project and six additional sets were converted fire control portables. The IEP sets were 8 watts while the fire control sets were only 0.8 watts. Without the more powerful IEP radios ground communications would have been completely inadequate.



Dr. Art Moore with the use of the transistorized aircraft frequency radio, directs the pilots making the smoke and spray runs.

Transportation

The transportation plans indicated 30 to 35 vehicles would be needed by project personnel. Most of the vehicles were provided by the General Services Administration. Other vehicles were provided by participating agencies, the Sawtooth National Forest, commercial rentals, and by individuals. Very little breakdown or mechanical trouble was experienced. Due to reduction in the size of the project, vehicles were not used as much as originally planned. A total of about 64,000 miles was driven at a cost of about $8,200 for a 12.8¢ per mile cost (not including record keeping and contracting costs). Where possible, on future projects, more use of privately owned vehicles would not only save the Government money, but would be a more efficient method of providing vehicles to project personnel.

Weather

Because of the importance of air movements, meteorology played a most important part of this project. The following seven meteorologists worked directly on the project:

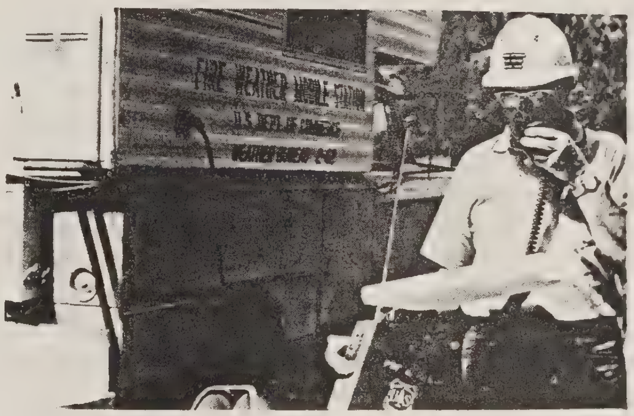
Name	Agency	Role
Garry DeMarrais	ESSA on Detail to IEP	Made literature review. Designed Project study plan. Directed weather data gathering on project. Spray & smoke behavior observer.
Chuck Syverson	ESSA - Fire wea. meteorologist	Operated mobile unit, daily weather reporting. Daily weather prediction for Big Smoky area. Spray & smoke behavior observer.
Dr. Ron Collis	Stanford Research Institute	Direct Lidar Gun work.
Dr. W. Johnson	Stanford Research Institute	Member of Lidar Gun crew.
F. G. Fernald	Stanford Research Institute	Member of Lidar Gun crew.
A. H. Smith	Stanford Research Institute	Member of Lidar Gun crew.
R. Hadfield	Stanford Research Institute	Office analysis of Lidar data.

In addition another meteorologist was detailed to the Boise Weather Bureau office specifically to feed area-wide weather information to Chuck Syverson on the project.

The following is taken from fire weather meteorologists report:

The Boise Mobile Weather Unit moved to the site of the Big Smoky Spruce Budworm Project on June 9. After sampling the radio reception in the lower valleys in the vicinity of Big Smoky Guard Station and in the upper Boise River and finding the reception inadequate, it was decided to set up a semipermanent camp for the mobile unit on the ridge at the south end of the Five Point drainage. From this vantage point, it was possible for the meteorologist to maintain a constant vigil on the weather during the 24-hour period, as well as to have an advantageous spot for viewing the weather that affected the spray-testing flights into the Big Smoky Basin from the south. Also it was possible from this point to gain an intimate feeling for the local weather and micro-meteorological factors affecting the test area of the Five Point drainage. Inasmuch as the test areas were at some distance from the main base station at the Big Smoky Guard Station and behind intervening mountains, it was very advantageous to have the weather station in a position to overlook the lower valleys.

Fire-weather meteorologist Chuck Syverson, gave the project up-to-the-minute information on local and area-wide weather conditions. Syverson was on the project about 30 days. Meteorologists played more important roles on this spray project than ever before. Future projects will see more and more use of meteorologists and better use of weather information.



The base camp was advised daily of the early morning weather conditions that might affect the spray testing plans. The first weather observation was taken by the meteorologist a little before 3 a.m. A report of the weather in the basins together with a preliminary forecast for daylight of the expected weather including temperatures and wind was radioed to the base camp at 3 a.m. On the basis of this early morning report and forecast for daylight, Base Operations could make plans for the activity that morning. Inasmuch as the spray planes for this testing had to fly from Gooding, it was desirable to have a couple of hours of advance notice of the expected weather picture.

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An early morning contact at 2:30 a.m. was made by radio between the Boise Mobile Unit and the Missoula Weather Bureau Office. At daylight, the meteorologist worked with the regular testing crew either as an observer or as an assistant. In order to do this, he moved his mobile unit to the site of the operations for the day. During the early morning operations, the late weather reports and data were received from the Fire-Weather Office at Boise by radio and facsimile. After the morning operations were terminated, the meteorologist moved back to his station and collected the weather maps and reports during the early afternoon. With this information, he prepared and issued a late afternoon forecast for the early morning operations of the next day. The collection of weather data, including local observations and weather map data, continued until about 10 p.m. By this time, it was usually possible to make any reliable revision to the late afternoon forecast if it were needed.

The mobile unit was equipped with a single side band transceiver capable of operating on six channels. One of these was the same channel used between the base camp, the Gooding Airport, and the Ranger Station at Fairfield. The mobile unit was equipped with radio facsimile equipment with which weather maps of many kinds at the surface and aloft were copied. Much of the weather data was copied by radio from both Boise and Missoula. When the budworm project activities were shut down for some reason, the work of the meteorologist continued in order that continuity of weather information was available.

Investigations of the meteorologists were performed to determine the effects of the stability and instability of the air mass upon the movement of the spray particles. Most of this work was to determine the movement of the air in the drainages and on the slopes, the depth of the valley inversions, the depth of the slope stability before sunrise, the instability after sunrise, the dissipation of the inversion, and other local air movements. All of these factors were observed and studied in order to predict the spread of the spray particles during these conditions. Another investigation was undertaken to explain the unusual effect of the differential heating between the Big Smoky Drainage and the Camas Prairie to the south around Fairfield. All of this investigative work was of vital importance to the success of the spraying operation as well as being very broadening in explaining the micro-meteorological conditions in the mountains.

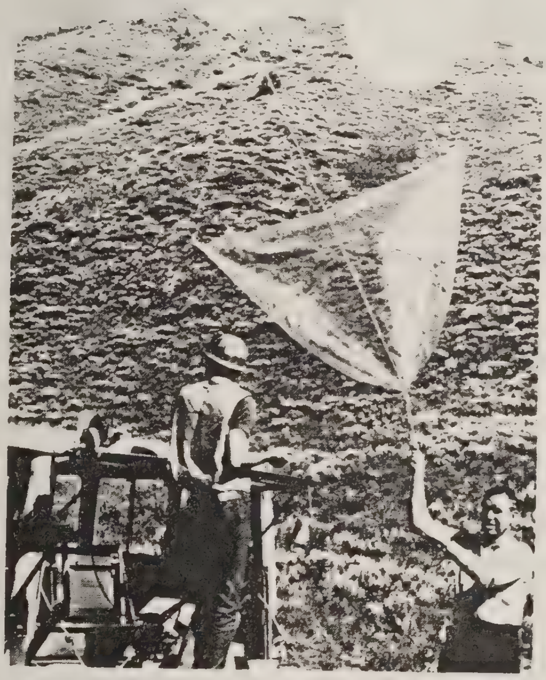
Inasmuch as the day of the fire—weather meteorologists usually averaged 19-20 hours each day, it would be of considerable advantage to have two meteorologists on an operation of this nature to man the Mobile Weather Unit.

The weather during the 1967 project period was cooler and more moist than other years. This weather problem caused a good many mornings of difficult stratus and fog, preventing the project from progressing as rapidly as had been expected. Also, the cool weather caused the spruce budworm to mature more slowly than expected. The weather was characterized by showery weather with thunderstorms, low clouds, and stratus.

A day-by-day summary of the weather is included in the Appendix. This gives some idea of the difficulties caused by the abnormally long, wet, cold spring.

Safety

The Forest Safety Plan and Program was adopted for this project. In addition



Meteorologists use two balloons and a tetroon to lift a wire-sonde 400 feet into the air. The wire-sonde measures temperature and electrically sends message back through wire to recording device (in back of vehicle). The instrument enables men to determine height of temperature inversion; vital information needed to predict the behavior of spray.

a supplemental plan was written and followed to cover the unique hazards associated with aerial spray projects. Apparently the plans were effective as only one first aid case (a knife cut on the hand) was experienced on the job. No vehicular accidents occurred. However, several incidents occurred to some of the project personnel during their off duty hours. It is strongly recommended that "home" safety emphasis be stronger on these camp based projects. It is also recommended that followup training and checking of Forest Service drivers be increased.

Because of the heavy use of aircraft as well as the development and experimenting with insecticide and spray equipment, the Air Operations Officer was assigned duties as Air Safety Officer. This strengthening of safety measures should always be followed on projects of this type.

EQUIPMENT DEVELOPMENT

On October 10, 1966, MEDC was asked to develop spray systems for three size-type aircraft as shown on the chart below.

The primary requirement was that the systems would produce all droplets under 50 microns in size (D-max 50) with a mass median diameter (mmd) of 20 microns or less.

	Min. Spray Speed MPH	Flow Rate Gal./Min.	Min. Load Cap. Gal.
Helicopter (rotor)	50	4	75
Single-eng. fixed wing	100	15	200
Multi-eng. fixed wing	150	45	1,000

The development crew consisted primarily of a Forest Entomologist working with an engineering design crew. Most of the work was carried out at the Missoula Equipment Development Center Laboratory. When the aircraft were delivered to the project air operations headquarters at the Gooding Airport the development crew came down and continued working on the equipment throughout the project period.

Many commercial nozzles were tested, some were designed by MEDC and tested but none were satisfactory. Among the types of nozzles tested were air-liquid double nozzles. These did produce the droplet size required but were impractical because the air compressor required to deliver air fast enough would weigh more than the gross weight of the aircraft.

In February of 1967, an attempt was made to mix Freon #12 (a common refrigerant gas in liquid form) and Dowanol DB (the insecticide carrier solvent) into a solution. This is the way insecticide aerosol bombs are made. It was felt, however, that Freon and the Dowanol were not mixing.* Because of the shortage of time it was not possible to determine in the laboratory what was happening so the method was temporarily abandoned. This method, however, led to the method which was adopted for the 1967 Big Smoky Project Spray System. The system was essentially two separate systems, one for the insecticide and one for the regrigerant gas. The systems used bifluid nozzles where the two liquids were mixed and discharged. This method produced droplets closer to the required size than any other system or nozzle tested except the impractical air-fluid system.

Using test stand techniques, it was determined that this system would produce an mmd of 35 with a D-max of 60. Time was becoming short so the 35 mmd and D-max of 60 was accepted rather than the 20 mmd and D-max of 50. The system was heavier and produced more drag that conventional systems, but it was judged to be aerodynamically sound and practical for the aircraft it was designed for.

During the last part of February, upon consultation with Dr. Moore from FSW-IEP, it was decided to develop the bifluid system for all three aircraft. Standard spray systems adopted for the helicopter and the Cessna 185 (single-engine fixed wing) while a new system would be designed and built for the C-47 (multi-eng. fixed wing). By the last of March, standard systems had been ordered for both smaller aircraft. The Cessna system was received on March 29, but the Bell Helicopter system was not received until May 8. Contracts were negotiated for modification, fabrication, and installation of all systems about the last of April with a separate contract being let on May 5 for fabrication of the three high-pressure refrigerant gas tanks.

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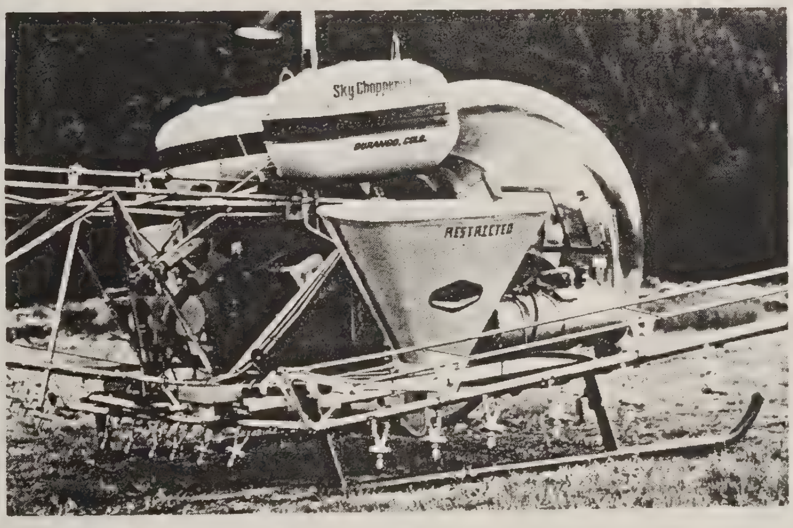
* It has now been determined that Freon does mix with the Dowanol, but a special nozzle with an expansion chamber is essential to produce the desired small droplets. The special nozzles were not used in the February 1967 trials and the desired results were not achieved. This system has now been successfully developed for the 1968 tests in R-1 and elsewhere.

All contracts were to be completed prior to June 1, which would allow the month of June for field testing to work the bugs out of the systems.

Because of an error by the Tank Contractor, the tank heads had to be recast. This caused a considerable delay and the first tank was not received until June 14.

The late tank delivery date prevented adequate field testing prior to the estimated spray date. Plans were to use the Cessna in simulated spray runs to be checked by lidar during the third week of June. It was also discovered before the Cessna was delivered to the Gooding Airport (Project Air Operations Headquarters) that the plane was underpowered for the intended use. In further checks at the Gooding Airport on June 18 and 19, the Air Operation's Officer, Jim Larkin, decided that the plane was unsafe. Due to lack of time rather than fix the Cessna, a TBM was rented. Karl Bryning, R-4 Air Operation Officer, took off to fly the Cessna to Twin Falls to check the Cessna's performance and deliver the Cessna to the TBM base for transferring the spray system. Bryning had to make an emergency landing in an alfalfa field shortly after takeoff.*



Boom arrangement and the bifluid nozzles on the spray helicopter. Spray equipment was designed by Missoula Equipment Development Center for 1967 Big Smoky Spruce Budworm Project.

The spray equipment was removed from the Cessna in the alfalfa field and trucked to Twin Falls that night. Working night and day, mechanics installed the spray system on the rented TBM which was delivered to Gooding for first tests on June 21 at 9:40 p.m. First actual spray testing was started the next morning with this equipment.

* We found out later that Region 9 had had trouble with this plane's performance when they tried to adapt it for use as a float plane. Upon inspection and testing by aircraft mechanics, it was found that the engine cylinders showed signs they had been run excessively hot at sometime in the past.

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The helicopter system was installed and ready for testing on June 22, while the C-47 system was not delivered to the Gooding Airport for spray testing until July 13. Late delivery of all three aircraft resulted in the MEDC personnel working long hours during the use period to test, alter, and adjust the systems to produce the smallest droplets possible.

The laboratory tests at Missoula resulted in mmd's of 35 or 40 with maximum drops of 120 microns with some tests as low as D-max 60. The field measurements of droplet sizes indicated mmd's of 70 to 80 microns and a D-max over 120 microns. It is believed, however, that this was the lowest mmd and maximum droplet sizes produced by any practical aerial spray system.

THE INSECTICIDE EVALUATION PROJECT

The Big Smoky Area was selected for the 1967 Zectran Pilot Project because it met the following requirements:

a. Reasonably accessible with good roads and trails.

b. Fairly mountainous terrain typical of the majority of the western mixed conifer forests.

c. Various slopes and aspects in the test area.

d. Relatively small, isolated budworm infested area.

e. A portion of the area with a moderate to heavy infestation.

f. Adequate fish streams for surveillance purposes.

It was Dr. Moore's intention to field test his transport and diffusion theories in two or three drainages, check them with the lidar gun and prepare spray prescriptions for each drainage of the test area. He would then train the project overhead in the new techniques during the first day or two of actual spraying and act as advisor while spraying was completed on the remainder of the area. In addition, Dr. Moore's responsibility included design of the entomological sampling procedures and development of the spray deposit sampling devices. The isolated infestation was desired to provide a history of reoccurrence after spraying.

Dr. Moore moved his crew to the project area during the last week of May. The crew consisted of Forest Entomologist, Dr. Moore; Forest Entomologist, George Downing; Meteorologist, Garry DeMarrais; and Technician, Hank Myer. The first week was spent in selecting, evaluating, and gridding three drainages for study. The week of June 6 saw the start of smoke runs to simulate spraying. By means of the grids and panels on the ground, the smoke drift could be observed and evaluated. These tests strengthened Dr. Moore's theories on spray transport and diffusion under different temperature weather conditions in different drainage patterns or structures. He soon was able to measure temperatures and recognize the weather conditions that caused the smoke to drift in predictable patterns.

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THE LOCATION: VALLEY [illegible]

Big [illegible] was selected [illegible] the following requirements:

a. Reasonably accessible [illegible]

b. Fairly mountainous terrain [illegible] with mixed conifer [illegible].

c. Various slopes and aspects [illegible]

d. Relatively small, isolated [illegible]

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Smoke was used because smoke particles are small and could be expected to best indicate the behavior of the spray particles. In order to check this assumption, the lidar gun was used the third full week of June.

A contract with the Stanford Research Institute to provide and operate the lidar gun was made during the planning phases. Dr. Ron Collis and his crew of research meteorologists arrived and set up their equipment on Sunday, June 18. They started their shooting on schedule the next morning. The following is taken from Dr. Collis' final report summarizing the work and results of the lidar gun crew:

> Lidar observations were made at two separate sites within the Sawtooth National Forest. Observations were conducted at the mouth of the Bridge Creek Valley (Fig. 2) from 18 to 25 June, and at the Five Points site (Fig. 3) from 29 June to 1 July, 1967.

Bridge Creek Site

The lidar was assembled, aligned, and checked out at the site on 18 June, at which time the equipment was used to record returns from

Neodymium lidar developed by Stanford Research Institute, Palo Alto, Calif. is used to track the minute droplets in the spray clouds. The lidar gun is a combination of radar and the laser beam who's output is in the near infrared. It penetrates haze better than the previous lidar models. Ronald Collis (right) of the Stanford Research Institute directs the work of the lidar crew.

Dr. Art Moore (left) and George Downing from IEP, Berkeley, prepare magnesium oxide glass slides. Slides are used to determine size of spray droplets. As droplets fall on mg. o. coated surface, they leave a cavity which can be measured by using a binocular microscope.

FIG. 2 LIDAR LOCATION AT THE BRIDGE CREEK SITE

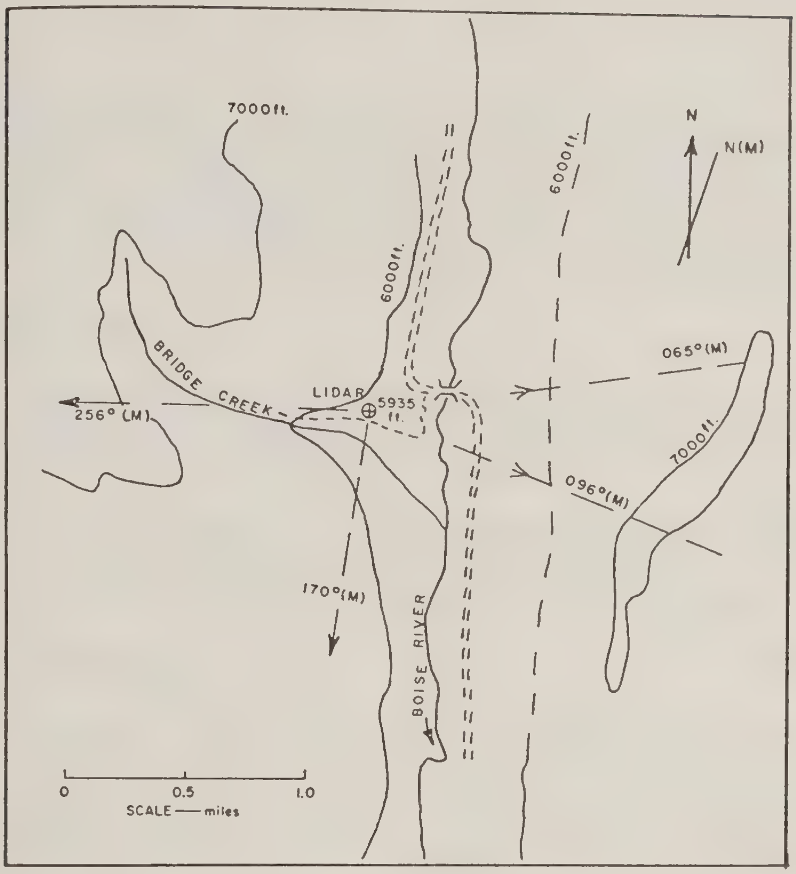
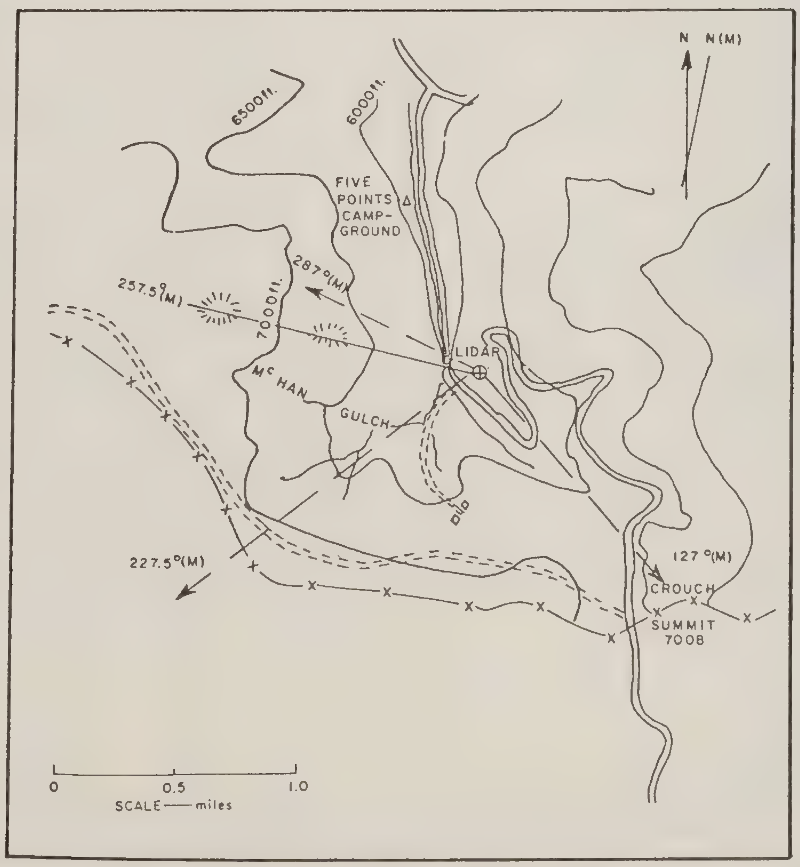


FIG. 3 LIDAR LOCATION AT THE FIVE POINTS SITE



the clear atmosphere and vertical profiles of the terrain at selected azimuth angles. Observations were subsequently taken of smoke dispensed from a Cessna and of spray dispensed from a TBM aircraft and from a helicopter. Selected portions of the data stored on a magnetic disc recorder were extracted, and a number of cross sections were plotted.

Five Points Site

The lidar was relocated to a site near the Five Points Campground on 29 June. This site commanded clear views across the upper drainage valleys of Five Points Creek and McHan Gulch.

Observations were made of spray dispersed by a TBM aircraft and a helicopter. These observations, and the reduction of selected data, followed the same procedure used at the previous site.

Equipment Performance

A minor equipment failure occurred in a power supply unit on 22 June. The cause of the failure was subsequently traced to an abnormally low voltage output from one of the gasoline-engine-driven generators, which was produced by erratic operation of the engine speed regulator. Repairs were made in time for the morning spray runs of 23 June.

Detailed Analysis of the Data

Because of limited time and facilities at the field site, the emphasis on the initial reduction of cross-section data was limited to establishing the boundaries of the spray clouds at various times. In addition, relative signal amplitudes received from various portions of the cloud were indicated qualitatively on several of the cross sections, to illustrate relative density variations within the cloud.

A detailed analysis was subsequently made of the observations, at which time the received signals were corrected for various equipment calibration factors, and a compensation for the inverse square law was introduced. The cross sections obtained from the corrected data represent the internal structure of the spray cloud in terms of relative backscatter contours. These contours provide estimates of the relative concentration of aerosols within the cloud, at different stages of the cloud development. The task of extracting data proved rather difficult. The ideal method, a fully computerized approach, could not be carried out readily because of limitations in the data record quality; in any event, the technique is cumbersome and costly for the relatively few data involved. The semi-automatic graphical techniques used, however, were quite successful and adequate for the majority of the data.

Conclusions

Lidar Techniques

The higher firing rate of the Mark V neodymium lidar used this year clearly extended the capability of the technique to investigate the motion and dispersal of insecticide sprays; in particular it was possible to study

SUMMARY OF LIDAR OBSERVATIONS

Date (1967)	Run	Time (MDT)	No. Shots Fired	No. Profiles Recorded	No. Profiles Plotted (Final Report)
			A. Bridge Creek Site		
19 June	A	0617-0638	18	--	--
	B	0641-0827	112	14	13
	C	0849-0938	216	27	10
22 June	A	1225-1237	41	2	2
	B	1308-1312	20	2	1
23 June	A	0737-0804	110	7	5
	B	0828-0857	170	7	6
	C	0921-0935	70	5	5
24 June	A	2008-2039	110	8	6
	B	2048-2104	120	5	2
	C	2115-2131	70	4	--
25 June	A	0812-0826	95	9	9
	B	0958-1012	60	6	6
	C	1030-1040	70	8	7
Approximate Totals on Spray and Smoke Observations, Bridge Creek Site			1282	104	72
			B. Five Points Site		
1 July	A	0540-0559	93	7	5
	B	0613-0659	300	12	10
	C	0713-0739	140	8	3
	D	0805-0856	305	14	12
Total, Five Points Site			838	41	30
TOTAL SPRAY AND SMOKE OBSERVATION (PROJECT)			2120	145	102

the location and motion of the spray cloud in two dimensions and in vertical sections.

The neodymium lidar was able to detect spray initially at ranges of up to 2 km and to monitor it for as long as 30 minutes after dispersal.

Attempts to evaluate the reflections of spray cloud and assess the dispersal and fallout quantitatively were not successful because of the limitations of the data processing and analysis techniques. In any case, however, variations in the way in which the spray was dispersed, particularly when multiple runs of the spray plane confused the issue, would have made such analyses of limited value. Useful data processing systems were worked out, however, and provided adequate analyses.

Computer analysis techniques which were tried showed considerable promise and could be applied in subsequent studies, now that the difficulties are better understood. Problems were encountered, however, in processing the recorded data for use in the computer, and this approach could not be followed economically.

Spray and Smoke Behavior

On the question of spray and smoke behavior, certain salient features emerge. First, it appears that visible smoke is a valid, but limited indicator of the motions followed by the invisible insecticide clouds.

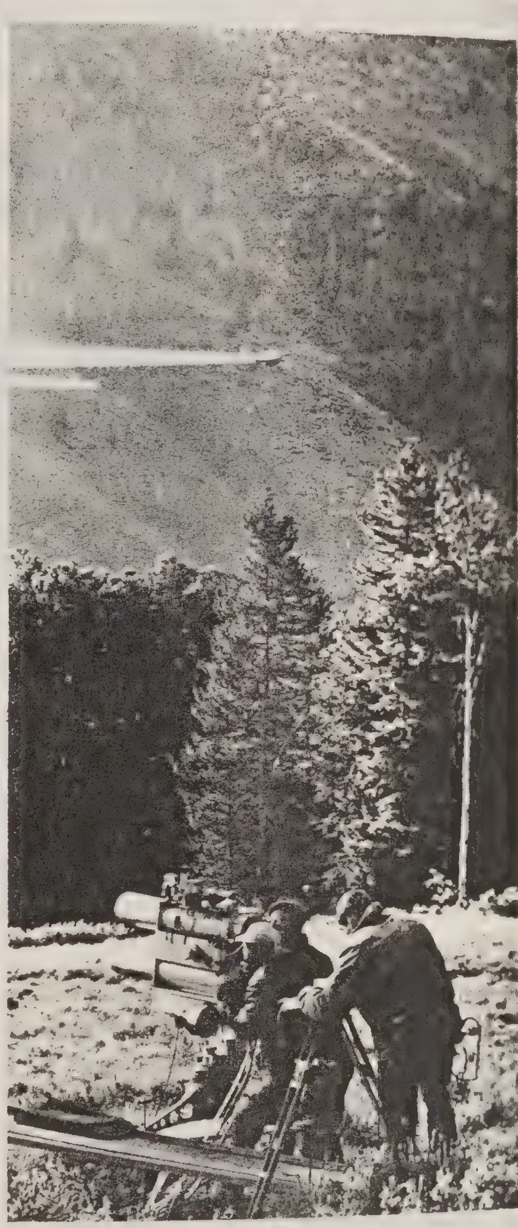
The latter, having considerably more material, disperse over larger volumes than do parallel smoke clouds, and their dispersal shows the effect of the fallout of heavy droplets. The fine drop spray suspensions, however, appear to behave in much the same way as the visible smoke clouds.

The motion of the spray clouds, under various meteorological influences, also appears to follow that indicated by the smoke and to be in conformity with expected convective and drainage air motions.

In particular, there is some evidence that in the stable presunrise conditions, spray clouds tend to stratify and spread out laterally. Where heating takes place, the spray clouds are dispersed vertically both up and down.

An interesting mechanical effect was observed in the dispersal of the spray by helicopter from low altitudes (i.e., below 50 meters above terrain). In this trial the spray cloud was seen to be driven down to the surface before rising in the convectively mixing air.

The motion of dispersal of the spray cloud under certain circumstances appears to be influenced by more general conditions than governed by the insolation of the valley



TBM spray plane (in lead) flying simulated spray run and Cessna 205 smoke plane laying down smoke, flying formation. Lidar crew made shots for a direct comparison of smoke versus spray. This information was used to determine atmospheric transport and diffusion of spray and smoke.

slopes. This was particularly so in the Five Points Drainage on 1 July, where the main drift of spray was not in accordance with the convective motions expected from surface heating.

Upon completion of the lidar gun work, additional smoke runs were made, aircraft spray systems prepared, and tested for droplet size, and final preparations made for spraying.

As noted in the Equipment Development section of this report, the droplet size finally achieved was not as small as desired. With larger droplets, much more insecticide was required to obtain the same coverage. In order to achieve the same results, it was necessary to increase the planned rate of spraying from 0.03 pounds of Zectran in one-half pint of

Atmospheric transport and diffusion of smoke plume laid down by the Cessna 205 smoke plane. Spread of smoke has been horizontal and has practically covered the whole valley bottom. This occurs under temperature inversion conditions.

DC-3 (C-47) spray plane and helicopter spraying in Salt Creek on July 15.

carrier (glycol ether) per acre to 0.06 pounds of Zectran in one pint of solvent.* A total of 2,305 acres was sprayed on July 15 at approximately this rate in the Salt Creek and Fleck Summit areas as follows:

	Helicopter	C-47	Total
Acres sprayed - Fleck Summit Area	385		
Acres sprayed - Salt Creek - Little Smoky Ridge	320		
Total Helicopter			705
Acres sprayed - Salt Creek		1,600	
Total acres sprayed			2,305
Gallons of insecticide used	73	250	323
Gallons applied per acre	0.104	0.156	
Pints of insecticide per acre	0.828	1.25	
Pounds of technical Zectran per acre	0.0497	0.075	

The map on page 27 shows location of spray areas and sample plots. Another responsibility of the IEP crew on this project was development of residue analysis techniques or methods for Zectran. The following is taken from the report on this work:

> You will note that the air samplers and the glasswool mats both gave inconclusive results. The foliage samples indicate a rapid drop in Zectran in the one-to-three-day sample period after spraying. The initial high Zectran level for Salsify on spray-day (7/15) is probably the result of spray system drool. Subsequent samples from this same location indicate very low Zectran levels.

Residue analyses: In 1966 a residue analysis was made on Douglas-fir and six browse species for Zectran as a result of forest aerial spraying. In 1967 this program of residue analyses was continued with several additions to the Douglas-fir and browse species sampling. (Table 1) Not only were these plant species sampled for subsequent residue analysis, but three other samplings were made:

1. Budworms spinning down after the spray and collected in drop cloths were analyzed for Zectran. Analyses indicated .15 to .34 micrograms per budworm.

2. Air samples. Very low levels of Zectran were expected due to spraying such low volume per acre and due to small droplet size, a more effective method of sampling and measuring was necessary.

* The dosage rate was 16 fluid ounces - just 1 pint--per acre! The advantages of applying such low volumes of material are numerous: Solvents and carriers are drastically reduced and mixing is eliminated. Storage and transportation costs are greatly reduced; and aircraft payloads cover a much greater acreage.

1967 BIG SMOKY SPRUCE BUDWORM PROJECT

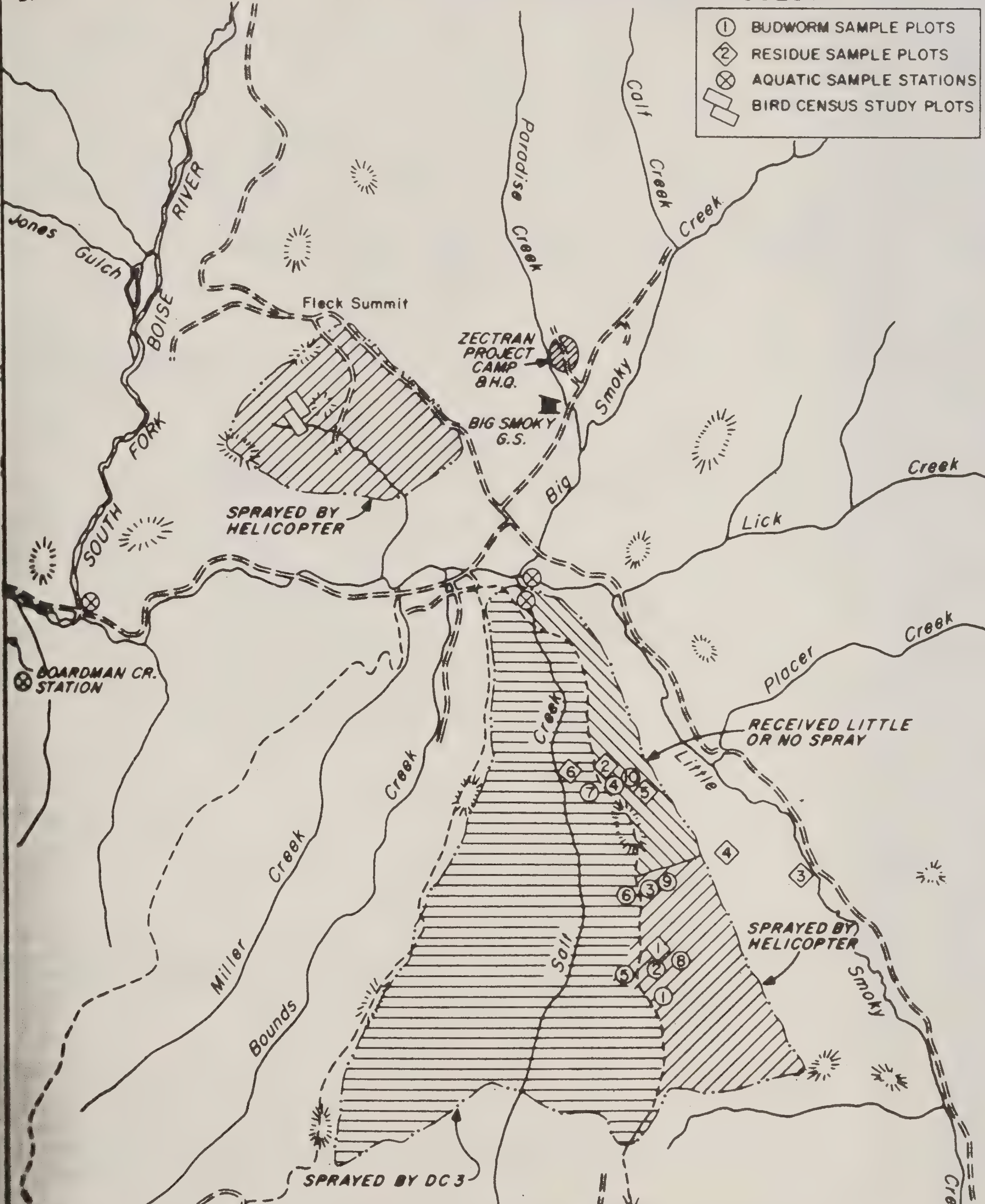


Table 1

Foliage Samples (ppm. Zectran, Idaho, 1967)

Plant sp.	Plot**	7/12 (Pre-spray)	7/15 (Spray-day)	7/16	7/18	% of Zectran Recovered***
Douglas-fir *Pseudotsuga menzlesii (mirb.) Franco var. glauca*	1	0	2.46	1.09	0.97	67
	2		0.75	0.07	0.00	
	5		0.29	0.07	0.07	
	(1966)*		(2.86)	(0.19)	(0.22)	(77)
Strawberry *Fragaria vesca* L.	3		2.09	0.13	0.00	47
	6	0	2.51	0.23	0.00	
	(1966)*		(6.25)	(4.17)	(4.50)	(48)
Salsify *Tragopogon dubius* Scop.	1	0			0.08	73
	4		159.24	0.07	0.00	
	(1966)*		(0.75)	(0.56)	(0.29)	(80)
Snowbrush *Ceanothus Velutinus* Dougl.	1	0		1.24	0.20	55
	2		0.35	0.18	0.25	
	5		0.51	0.00	0.60	
Arrowleaf Balsamroot *Balsamorhiza sagittata (Pursh) Nutt.*	1		2.92	4.13	3.64	77
	2		0.61	1.04	0.07	
	4	0	0.18	0.07	0.30	
(Balsamorhiza-different species)	(1966)*		(7.85)	(0.47)	(0.33)	(85)

* 1966 samples were obtained from spray project on Bitterroot National Forest where Zectran was applied at rate of .15 lbs/acre.

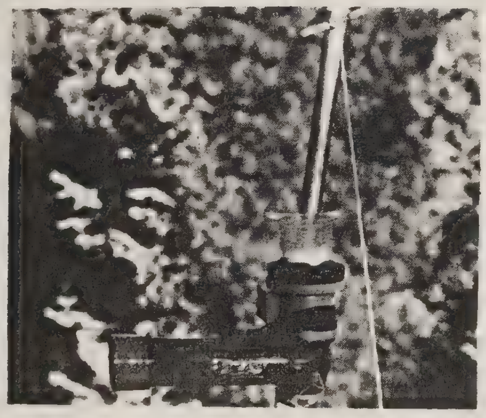
** These plot locations do not correspond to the insect sampling plot locations. The locations of both the insect sampling plots and the foliage sample plots are shown on the map page 27.

*** This is the percent of Zectran that can be recovered by the laboratory recovery methods used. For instance, the 2.46 ppm. of Zectran reported for the July 15 sample of Douglas-fir is only 67% of the Zectran that landed on the fir foliage.

The commercial high-vol. air samplers were quite expensive; therefore, inexpensive battery-operated hand vacuum cleaners were adapted. These vacuum cleaners were modified to collect small aerosol type droplets, standardized for airflow and by the use of guyed tubing situated to collect air samples at different heights on nine sample plots, for one hour after spraying. Analysis of these samples indicated poor correlation between biological effect at these stations and the air samples, although it was shown that Zectran was collected by the samplers.

3. Glasswool: Glasswool mats of 480 cm^2 were also suspended with the air samplers to act as impinging devices for the spray. These also were capable of intercepting spray drift, but no correlation between recovery and insect mortality was proved. Residue samples from plants indicate a very rapid degradation of Zectran occurs in one day.

Apparently, more work needs to be done to determine why no correlation was found or to develop some other method that can be used as a key to expected insect mortality.



A rather simple mechanical air sampler was tested on the 1967 Big Smoky Spruce Budworm Project to see if the air sampler would adequately sample the spray deposited in aerial spraying. A small motor is attached to a flashlight body where the light would normally be. The motor runs a fan which draws air through a filter in the top. The filters were removed after spraying and analyzed chemically to see how much spray was caught.

AIR OPERATIONS

An Air Operations Air Safety Officer position was established early in the planning phases of the project. Jim Larkin, Region 4 Western Zone Air Officer, was assigned to the position to work with MEDC in Air Worthiness and Safety in the design of the spray equipment.

Arrangements were made for use of a portion of the Gooding Municipal Airport as Air Operations Headquarters. A 27-foot trailer was located there. Water, electricity, radio, and telephone communications were connected to the trailer. The Gooding Airport has three paved runways which are all just under 5,000 feet long. There was very little other traffic at the Airport, yet there were aircraft mechanics and other services available. The choice of Gooding for Air Operations was a good one.

The helicopter operations were based at the Big Smoky Camp, but were still under direction of the Project Air Operations Officer. A list of the project aircraft, hours of flight, cost per hour, and function is included in the appendix.

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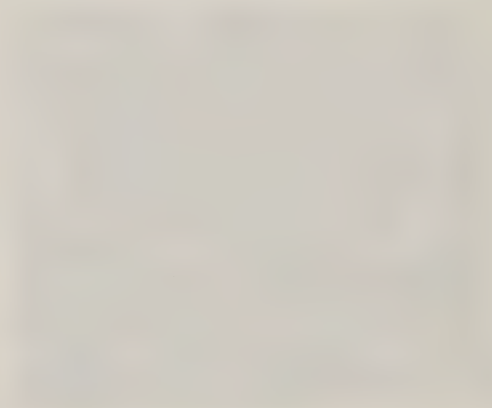

XII. [illegible]

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The following is taken from the Air Operations Officer's Report: "Air operations began on the 1967 Big Smoky Spray Project on June 5, 1967, with the installation and initial use of a contract 205 Cessna, equipped with a Skip Craft Aero Smoke system. Sun Valley Airlines furnished this airplane and crew, with Jim Wilken, owner and manager, doing most of the flying. This unit functioned very satisfactorily. Also on June 5, a Helicopters Inc. helicopter, piloted by Dan Danielson, began project recon work; many flights were made to sample temperature gradients, inversion levels, and in laying out panels for grid identification.

Severe heating problems were encountered with the Forest Service Cessna 185 spray plane. Two evaluation flights were made from the Gooding Airport by Forest Service pilots, McEntire and Larkin. The decision was made to ferry the airplane to Twin Falls to remove the spray equipment and reinstall the system in a Reeder Flying Service TBM.

Regional Air Officer, Karl Bryning, flying the spray plane left the Gooding Airport for the fifteen minute ferry flight to Twin Falls on 6/19/67 at 10 a.m. A short time after takeoff, he encountered extremely high oil temperature, a loss of oil pressure, and loss of power. Unable to sustain flight, he successfully landed the airplane in an alfalfa field on the Johnson farm, five miles east of Wendell, Idaho, with no damage to the airplane or spray equipment. The spray system was then removed and installed on a Reeder TBM in a crash overnight program. The Cessna was dismantled and taken to the Twin Falls Airport for reassembly and engine repairs. Bugs were worked out of the TBM installation, and several successful spray flights were made for Lidar observance.

Mountain West Helicopters, Provo, Utah, were, meanwhile, installing the MEDC spray gear on their Bell G-3B helicopter. It arrived at Gooding on 6/21/67, again under the gun to start spraying before release of the Lidar Unit. Problems encountered were: No paper work on any of the installation, the helicopter being flown to Gooding on a ferry permit. Rush arrangements were made with the FAA in Boise, the GADO inspector, Mr. Meyenberg flying to Gooding in a Forest Service Aero Commander. Necessary paper work, a form 337, the installation weight and balance, etc., was accomplished by George Smith, Sun Valley Airlines mechanic, and field approval was granted by Mr. Meyenberg on the same day. No further major problems were encountered with the spray helicopter.

The Forest Service C-47 spray system was plagued with fabrication problems during the months of May and June. What started out as a three weeks contract by Hillcrest Aviation, Lewiston, Idaho, dragged out for over two months at first, the Freon tank manufacturer had to recast the heads of the tank which delayed building the tank, finally completing it on June 26, 1967. The tank was rushed to Lewiston by Forest Service Pickup. Lateness of the season placed the contractor in an almost untenable position, as mechanics were scattered to the four winds on seasonal commitments. Finally, the system was ready for the pump installation. At this time, the supplier admitted that he had the engine, but the pump was due in "a few days." The extreme lateness of the season necessitated converting a MEDC fire pump, and this was installed in the system. The C-47 was ferried to Gooding on July 13, 1967.

The biggest operational problem encountered on the C-47 was drag. The first installation had the freon boom mounted 4" above the spray boom. The aircraft was flown in an empty configuration on June 27, 1967, with 150 Stull bifluid nozzles installed. The drag was found to be intolerable. The booms were then changed to a tandem trailing configuration. This reduced the drag somewhat. Nozzles were removed at Gooding until an operational number of 96 was arrived at.

The Stull bifluid nozzle, with associated plumbing, appears to be the primary source of drag. The airplane was flown during spray operations on July 15 with a load of 250 gallons of Zectran spray, 200 gallons of Freon on board, and loaded with 340 gallons of fuel. Rate of climb was 200 feet per minute, severely limiting the operational performance of the airplane. The only plus factor on this boom installation was being able to make quite steep down hill runs at the recommended spray speed of 150 mph, and still carry power requirements. Cleaning up the external part of this system should be number one priority in arriving at an efficient installation."

Insecticide Loading

Separate insecticide storage and loading facilities were established at the Gooding Airport for the fixed wing aircraft and at the Big Smoky Base Headquarters for the helicopter. Separate loading systems were needed for the insecticide and the liquid gas (Diclolorodifluoromethane, a refrigerant gas) at each location. A 2,000 gallon tanker trailer antibiotic mixing tank was obtained from Region 1 for pumping the insecticide at the airport. A simple barrel pump was used for the helicopters.

The refrigerant gas, Neon 12, presented a problem. It was finally decided to use nitrogen, a gas bottled under high pressure to push the Ucon 12, which was under lower pressure, into the aircraft spray system tank. This system worked rather slowly and we found the temperature of the cylinders had to be kept under 70°F. to reduce pressure. Unless controlled by cooling with water and covering with tarps the temperature of the cylinders rose

Air Operations area and insecticide loading area at the Gooding, Idaho, Airport. Zectran chemical in barrels to the left, mixing tank next, then large cylinders of Ucon gas in front of aircraft. Note small cylinder of nitrogen between first two Ucon tanks on right.

Workers load insecticide and Ucon gas in TBM aircraft. Insecticide is being loaded. Don Cahill, Equipment Development Center, adjusts valve on bottle of nitrogen gas which is used to force the Ucon out of the large tanks.

rapidly in the hot afternoon sun. Normal night time cooling did not reduce temperatures below 70 degrees. Enough insecticide, Ucon 12, and nitrogen was ordered to spray 64,000 acres. This consisted of 80 55-gallon barrels of Zectran, 15 one-ton cylinders of Ucon 12 and 101 cylinders of nitrogen gas. We actually used only a small portion of this material in spraying the 2,000-acre reduced area.

It took two men at each location to operate the loading systems. These men were trained and worked under the direction of the Missoula Equipment Development Center personnel.

ENTOMOLOGICAL PHASES

Harold Flake was assigned the job of project entomologist and was responsible for determining rate of larval development, budworm population (pre- and post-spray), percent parasitism (pre- and post-spray), collection of spray residue samples, and the placement and operation of mechanical air samplers in the field. All the work of the entomological crew was coordinated with the work of IEP and other project activities to ensure that sufficient plots were established and sufficient and pertinent data collected to adequately support Dr. Moore's studies.

A laboratory was established at Gooding, 60 miles from the Big Smoky Base Camp. This enabled us to hire 6 local college girls to do the lab work and also was handy to cold storage facilities for storing foliage samples. With crews collecting samples in the woods and girls examining the samples in Gooding 60 miles away, the entomologist spent too much time traveling which left too little time for crew and lab supervision. If the same conditions prevailed on another similar project, I would strongly recommend the lab being established at the same place as the base headquarters.

The field crew was composed of 16 men; an assistant to the entomologist and three, 5-man crews each responsible for an assigned unit of the project. I feel it was demonstrated this number of men is adequate to sample a much larger area than the 64,000-acre area.

A separate report was written by the project entomologist on his phases of the work. The following is taken from his report:

The infestation of the western budworm, Choristoneura occidentalis Freeman, has fluctuated between 13,000 and 80,000 acres in mixed conifer stands of the Sawtooth National Forest since 1952. The results of the 1966 egg mass, ground, and aerial surveys showed 60,000 acres of host type timber would be infested in 1967. The predicted damage classes for the infested area in 1967: heavy - 8,700 acres; medium - 8,300 acres; light - 43,000 acres.

Larval development.--The cold weather of May and June retarded larval development from what had been considered normal for the area. Weather records show the period was one of the coldest and "wettest" on record. During early June, the period when the second instar larvae were emerging from their hibernacula, the spray area had frequent rains, 12 out of the first 16 days, and few days the temperature was above 65°F. for any extended period of time. The threshold temperature for budworm feeding is 50°F. The second instar larvae emerging under these unfavorable weather conditions were probably unable to establish themselves in the closed buds and on the very limited amount of new foliage; considerable mortality of the second instar larvae probably occurred at this time.

On June 8, the larvae were still observed in their hibernacula and the first confirmed budworm larvae emergence was not observed until June 11. Budworm larval development was considered to be a week to ten days behind the normal development rate for the area. Populations were found to be considerably less than we expected from the predicted damage classes. As sampling continued, the only substantial populations were located along ridge tops. Some mortality at lower elevations may have occurred when the emerging larvae were unable to establish themselves due to the cold wet weather. On plot 12, first sample was made on 6/28 - most larvae in 3rd and 4th instars. By 7/6 there were no larvae left in 2nd instars - most were in 4th and 5th - larvae development was prime for spraying from 7/6 to 7/12. Spraying was not completed until 7/15, due to delays in preparation of the spray equipment. Development samples indicated some larvae had already formed pupae.

Plot selection.--Forty mortality plots were selected by IEP personnel on the proposed 60,000-acre area from aerial photos and a photo mosaic of the spray area. On June 28 and 29 the 40 mortality plots were located and marked on the ground and were sampled to determine population levels and larval development. Only five plots (2, 12, 27, 36, and 40) of the original 40 had high enough population levels to determine mortality caused by the Zectran spray. On July 3, the area surrounding each of these plots was sampled in an effort to find an

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[illegible] report [illegible] project [illegible] the following [illegible]

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[illegible] caused by the Zectran spray. On July 3,
[illegible] was sampled in an effort to find an

area of several thousand acres of high budworm population in which to spray. From each plot center, the field crew sampled in three directions. Samples were taken at 100- and 200-yard intervals from the plot center in each of three directions. On July 4, the area was struck by a severe hail storm. The hail stones were one-half inch in diameter. The results from the sampling on July 3 were considered to be unreliable due to the budworm mortality caused by the hail storm, so the five areas were again sampled on July 5. In this sampling, the five plots were sampled in four directions from each plot center. Samples were taken at 100- and 200-yards from the plot center for each of the four directions.

Only plot 12 had the budworm population necessary to evaluate Zectran.

The proposed spray area was reduced from 60,000 acres to 2,300 acres in the vicinity of plot 12 because of low budworm populations.

Spruce budworm mortality sampling.--Ten plots, 8 trees each, were selected along the ridge in the area of plot 12.

Pre-spray samples were taken on July 14, the area was sprayed on July 15, and post-spray samples were taken five days later on July 20. The results are summarized in the table on page 35. As with any spray project, a number of factors need to be considered in properly assessing the results. The original plan was to spray before any pupation; however, a delay in arrival of spray equipment for the DC-3 resulted in over 14 percent pupation by spray day. No assessment of pupal mortality was made, but laboratory tests by the IEP indicate that pupae are about as susceptible to Zectran as budworm larvae.

The project entomologist established a laboratory at Gooding, Idaho. Six girls were hired and trained to examine the foliage and find the spruce budworm larvae. With the use of binocular microscopes, they measured head capsules to determine larvae development. This information was used as a basis for determining when the spruce budworms were ready for spray.

Number of spruce budworm in pre-spray and post-spray samples from Zectran treatment area, Sawtooth National Forest, 1967.

Plot	Pre-spray 1/			Post-spray 2/			Larval reduction
	Larvae	Larvae per 100 buds	Pupae	Larvae	Larvae per 100 buds	Pupae 3/	
	Number						Percent
1	41	2.57 ± 0.97	4	3	0.10 ± 0.06	10	95.70 ± 2.49
2	86	4.16 ± 0.80	35	1	0.04 ± 0.04	12	99.13 ± 0.90
3	94	5.01 ± 1.86	4	14	0.40 ± 0.09	14	91.95 ± 2.10
4	92	2.82 ± 0.49	13	136	1.86 ± 0.36	97	35.03 ±14.97
5	16	1.30 ± 0.24	0	0	0.00 ± 0.00	0	100.00 ± 0.00
6	58	2.68 ± 0.68	2	2	0.05 ± 0.05	11	98.70 ± 1.28
7	51	2.12 ± 0.52	3	11	0.30 ± 0.07	30	88.13 ± 2.37
8	45	2.16 ± 0.20	0	1	0.03 ± 0.04	1	98.66 ± 1.48
9	40	1.77 ± 0.53	1	11	0.28 ± 0.16	14	90.04 ± 5.04
10	75	1.80 ± 0.41	14	32	0.45 ± 0.08	100	74.01 ± 8.11
All plots	598	2.58 ± 0.24	76	211	0.53 ± 0.03	289	75.61 ± 5.36
W/o 4 & 10	431	2.75 ± 0.32	49	43	0.17 ± 0.04	92	94.37 ± 1.05

1/ Sample consisted of four 15-inch branches per eight trees per plot.
2/ Sample consisted of 10 15-inch branches per eight trees per plot.
3/ Figures include both live and dead or dying pupae.

Plots 4 and 10 received little or no Zectran because the DC-3 shut off the spray before reaching these plots, and the helicopter spray load intended for this area was lost enroute when a plug worked loose in the spray boom.

Budworm reduction on the 10 plots, including pupae, was 45.6 + 8.6 percent and without pupae 75.6 + 5.4 percent. Budworm reduction on all plots, except 4 and 10, including pupae, was 82.4 + 2.9 percent and without pupae 94.4 + 1.05 percent. The above figures have been adjusted by bud counts (number of live tips) to account for differences in sampling intensity.

The number of surviving budworm larvae are also given in the table. For all plots, 0.53 + 0.03 larvae per 100 buds survived, and for all plots, except 4 and 10, 0.17 + 0.04 larvae per 100 buds survived. There was an average of 50.5 buds per 15-inch branch sample. Figures are not available on pupal survival, as pupae from post-spray samples were not held over, as it takes about 2 weeks holding time after spraying to determine pupal mortality.

The size of the spray area, the timing of the spraying and the low population were all factors which contributed to confuse the data and lead us to question the reliability of the results of this test of Zectran. However, budworm mortality for all but the two missed plots (4 and 10) compares favorably with several previous tests with Zectran at 2.4 ounces per acre.

Budworm parasitism (pre- and post-spray).--The larvae were not reared for percent parasitism determination because of the advanced stage of larval development on the spray date. It was felt that no meaningful conclusion on parasitism could be made without a good distribution of the larvae in the third to the sixth instars.

Mechanical air samplers.--It was the responsibility of the entomological crew to place and operate the residue sampling devices described earlier in this report. The air samplers were inexpensive battery operated hand vacuum cleaners. These vacuum cleaners were modified to collect the small aerosol-type droplets, standardized for airflow and by the use of guyed tubing situated to collect air samples at different heights on nine of the ten sample plots, for one hour after spraying. Analysis of the filters taken from these samples was made in the IEP lab at Berkeley.

SURVEILLANCE

For the purposes of this administrative study, surveillance consisted of collecting information and assessing the effects of the spray on the environment. The surveillance work included both terrestrial and aquatic studies. The terrestrial surveillance was under the direction of Dick Pillmore from the Bureau of Sport Fisheries and Wildlife Office in Denver. The aquatic surveillance was conducted under direct project supervision with the cooperation of personnel from the State of Idaho Fish and Game Department.

a. Terrestrial surveillance.--The abstract from Dick Pillmore's formal report follows:

"ABSTRACT: Songbirds and small mammals were censused on a 400-acre wildlife study area sprayed July 15th with 1 oz. per acre of

Terrestrial surveillance was conducted by personnel from the Bureau of Sport Fisheries and Wildlife Denver Wildlife Research Lab. Biologist Dr. Richard Pillmore tapes bird calls before, during, and after the spraying. This new surveillance technique enabled Pillmore to sample more locations with a limited number of men.

Personnel from the Denver Wildlife Research Lab trapped small mammals, marked them, weighed them, and recorded other data and then released them. The activities of these marked animals were watched day by day before, during, and after spraying to determine affects Zectran might have on the wildlife population.

"aerosolized" Zectran, an experimental carbamate insecticide for spruce budworm control. Censusing was concentrated on two 20-acre plots in the forest and an adjacent sagebrush-grassland opening within the Douglas-fir zone of the Sawtooth National Forest, Idaho. Songbirds were studied by conducting breeding-bird census and trend counts, observing nests, and mist-netting for marking. Although the data were too sparse to make firm conclusions, comparisons of pre- and post-spray counts and our general observations revealed no effects of the spray.

Small mammal trapping yielded one flying squirrel and 25 chipmunks in 576 trap nights. Neither the small amount of capture-recapture data nor general observations indicated any insecticide effect on the chipmunk population."

Dr. Pillmore concluded his report as follows:

> Failing to measure and observe any detrimental effects of Zectran applied in an aerosol, we concluded that the exposed songbirds and small rodents suffered no adverse effects. Of course, failure to show adverse effects does not prove safety to wildlife, but it does indicate definite progress in the search for safer insecticides and better application methods.
>
> Evidence of Zectran's safety can be strengthened through improved study design and methods. With the very limited manpower and so many uncontrolled variables, the resulting data were highly variable, difficult to interpret, and too sparse for statistical analysis. Field study methods may be improved by increased use of automatic data processing for more complete and complex data analyses, better-trained observers, and better experimental design with comparisons or more than one spray application and with replications for both sprayed and unsprayed study areas.

b. Aquatic surveillance.--The aquatic surveillance was under the direct supervision of two Region 4 Fisheries Biologists; Bill Platts from the Payette National Forest assisted by Howard Metsker from the Ashley National Forest. A sophisticated sampling technique was carried out night and day, before, during, and after spraying. Following are results and conclusions taken from Bill Platts' report:

Results

Aerial spraying started on July 15, 1967, about 0630 and was completed by 0830. The first increase in drift insects was noticed in Salt Creek at 1000. This was mainly adult Diptera. The increased drift lasted until 1500 when numbers of drift insects returned to normal. The data shows that adult Diptera were affected by the application of Zectran. This increase in Diptera numbers did not occur in the control stream or the other two monitoring streams. Spray operations in the South Fork Boise River and Little Smoky Creek drainages did not ever come close to the main stream. In the Salt Creek drainage, Zectran spraying was done on both sides and across the stream.

Mean insect drift numbers collected at the monitoring stations gradually decreased as water discharge rates decreased, except Salt Creek which, because of the spray operations, increased during this period. On July 17 a heavy rain occurred and although Zectran is not water soluble, there seemed to be an effect on the aquatic insect population, as drift of immature aquatic Diptera again increased following the rain. Changes in other insect populations considered to be sensitive species, e.g. Ephemeroptera, Plecoptera, and Trichoptera, did not develop which tends to demonstrate that the Zectran was having very little effect on the aquatic life.

Water temperatures taken at time of insect drift collections showed that temperature conditions during the monitoring period were favorable to fish survival. Stream flows were assessed at the start of insect drift sampling and towards the end of insect drift sampling. Stream flow fluctuation was extreme, almost leaving some sample points out of the water flow area.

Electro-shocking of the designated sample areas was done to obtain gross indications of fish populations. The same area was sampled in each stream on both occasions. The results showed there was no noticeable decrease in fish populations in the small areas sampled. There was a noticeable decrease in Rainbow Trout found in Little Smoky Creek from the pre-spray to post-spray period. This can be explained by the stocking of catchable trout just prior to pre-spray electro-collection and the heavy fishing pressure exerted over the July 4 holidays between pre-spray and post-spray electro-collection.

Miscellaneous

Fisheries Biologist Bob Bell of the Idaho Fish and Game Department assisted in planning the surveillance program and in the electro-shocking fish collection.

Conclusion

Zectran used in the amounts and under the conditions of this study did not show any adverse effects on the fishery resource or the aquatic habitat.

SUMMARY

The objective of the 1967 project was to control the Big Smoky Spruce Budworm infestation and, at the same time, test and perfect the latest Zectran formulations and the new application techniques under large-scale project conditions.

The 1967 Big Smoky Spruce Budworm Project was designed as an administrative study of the application of the insecticide Zectran against the spruce budworm. To meet the objectives three specific areas of study were spelled out in the plan:

1. To field test the effect of Zectran on budworm larvae. One pint of glycol ether containing 0.03 pounds of Zectran was to be sprayed by aircraft in droplets of 1 to 50 microns in diameter.

2. To determine operational potential of three types of spray aircraft for applying Zectran in low volume, micro-size droplets, by taking advantage of atmospheric transport and diffusion in spray operations.

3. To test mechanical air samplers as aids in spray deposit assessment.

Of primary concern at this stage of testing was the development of spray equipment to produce the small droplets. Without the small droplets neither atmospheric transport and diffusion nor the mechanical air samplers could be adequately tested.

The responsibility for the development of the spray equipment was given to Missoula Equipment Development Center in the fall of 1966. By February their lab tests indicated that mixing a gas in liquid form with the insecticide in a bifluid nozzle before releasing to the atmosphere would give the desired range of drops. They designed systems for a helicopter, a light single engine fixed wing plane, and for a multi-engine transport plane. Contracts were let for the manufacture of these spray systems, but were not completed in time for field testing and adjustment prior to use on the project. It was disccvered on the project that the equipment did not produce the same range of drops as the laboratory tests indicated. However, the range of drops produced was smaller than ever before achieved on aerial spray projects.

An intensive survey in the fall of 1966 indicated we could expect a moderate to heavy infestation on about 31,000 acres and light populations on 78,000 acres in the project area. Precontrol surveys indicated that this predicted population did not develop.* By diligent searching during June an area of 2,000 acres was found with enough budworm population to indicate success or failure of the insecticide, the spray equipment, and the new spraying techniques.

* It was the concensus of the several entomologist on the project that extreme weather conditions during the winter and a long cold and wet spring reduced the budworm population to almost endemic conditions.

Objectives of the 1957 project were to [illegible] control the Big Smoky Spru[illegible] infestation and, at the same time, test and perfect the latest formulations and the new application [illegible] under large-sca[illegible] conditions.

[illegible] Big Smoky Spruce Budworm Project ... designed as an operatio[illegible] study of the [illegible] of the [illegible] against the budworm. To meet this ob[illegible] specific areas of scu[illegible]

To field test the effect of [illegible] budworm larvae [illegible] of glycol ether containing 0.05 [illegible] was [illegible] sprayed by aircraft [illegible] droplets of 1 [illegible] 50 microns in diameter.

To determine operational potential of three types of [illegible] craft for applying [illegible] volume, micro-size [illegible] taking advantage of atmospheric transport and diffusion [illegible] spray operations.

To test mechanical air samplers as aids in area [illegible] ment.

[illegible] concern at this stage of testing was the devel[illegible] to produce the small droplets. Without the small droplets [illegible] atmospheric transport and diffusion for the mechanical [illegible] could be adequately tested.

Responsibility for the development of the spray equipment was given [illegible] Missoula Equipment Development Center in the Fall of 1956. By [illegible] [illegible] tests indicated that mixing [illegible] in liquid form with the [illegible] in a bi-fluid nozzle before releasing to the atmosphere would [illegible] desired range of drops. They designed systems for a helicopter, [illegible] single engine fixed wing plane, and for a multi-engine [illegible] Contracts were let for the manufacture of these spray systems [illegible] completed in time for field testing and adjustment prior [illegible] project. It was discovered on the project that the equipment did [illegible] produce the same range of drops as the laboratory tests indicated. [illegible] the range of drops produced was smaller than ever before achieved [illegible] spray projects.

[illegible] survey in the fall of 1956 indicated we could expect a [illegible] infestation on about 31,000 acres and light [illegible] the project area. Precontrol surveys indicated that [illegible] not develop [illegible] by diligent searching [illegible]
[illegible]
[illegible]

Because the equipment did not quite meet the objectives and because of the budworm population reduction, it was decided to reduce the project spraying from 64,000 acres to 2,000 acres.

The second area of study, atmospheric transport, and diffusion in spray operations, was pursued by Dr. Arthur Moore and his team of scientists from the Insecticide Evaluation Project, Berkeley, California. A light plane was equipped with a smoke generator and extensive simulated spray runs under various temperature and weather conditions were made. Patterns of smoke behavior were noted. The scientists were able to accurately predict smoke behavior for different weather conditions and drainage structure.

To see if the spray would act the same as smoke, when released over a drainage, simulated spray runs (using only the Zectran carrier) were made. Because the spray became invisible shortly after being released from the plane, a lidar gun was used to track both the smoke and simulated spray runs. (The lidar gun is a laser beam combined with radar. The laser beam is shot into the cloud of smoke or spray particles and reflected and recorded by radar. Size, density, and distance are recorded on instant replay recording and storing equipment.) Art Moore's team, using simulated smoke and spray runs and the lidar work, was able to confirm that atmospheric transport and diffusion of minute spray droplets has great potential in increasing effectiveness of the spray and reducing contamination of nontarget organisms.

On July 15 approximately 2,300 acres were sprayed with Zectran using the new techniques of atmospheric transport and diffusion. Budworm populations in the area were reduced an average of 94 percent in the sprayed area. Surveillance of both terrestrial and aquatic forms revealed no adverse effects due to spraying.

Testing mechanical air samplers, as an aid in determining spray deposit of the minute droplets, was the third study area undertaken for this project. Flashlight battery powered air pumps were developed. Air was pumped through filter paper. After spraying, the papers were sent to the lab for chemical analysis of the trapped deposit. Some difficulty was experienced in recovering the deposit due to recovery equipment breakdown. Techniques of recovery and analysis need improvement. The air samplers worked as designed, but for some undetermined reason no correlation could be found between insect mortality and residue recovery on this project. Further work on this method may prove beneficial.

In terms of cost per acre this was perhaps one of the most expensive aerial spray projects ever undertaken. In terms of objectives and accomplishment more was attempted on this project than ever before. Solid advancements in spray equipment development, atmospheric transport and diffusion techniques, and spray deposit assessment were made. It was demonstrated that these advancements could be applied on future aerial insect control projects. The 1967 Big Smoky Spruce Budworm Project was the turning point in the search for a substitute for DDT for use against the spruce budworm.

[illegible] objectives [illegible] it was decided to reduce the [illegible] from [illegible] acres.

[illegible] of [illegible] atmospheric transport, and diffusion in spray [illegible], were [illegible] Dr. Arthur Moore and his team of scientists [illegible] the Insecticide [illegible] Project, Berkeley, California. [illegible] equipped with [illegible] temperature and [illegible] under various [illegible] weather conditions [illegible] made. [illegible] smoke behavior were [illegible]. The scientists were [illegible] to accurately predict smoke behavior [illegible] different weather conditions and [illegible] structure.

To see if the spray would act the same as smoke, when released over [illegible] simulated spray [illegible] using only the Zectran [illegible] were made. [illegible] the spray became invisible shortly [illegible] released from the plane, a Lidar unit was used to track both the smoke and spray runs. (The Lidar unit is a laser beam combined with [illegible] laser beam is shot into the cloud of smoke or spray [illegible] reflected and recorded [illegible] size, density, and [illegible] instant replay recordings and [illegible] simulated smoke and spray runs and the Lidar [illegible] that atmospheric transport and diffusion of minute [illegible] has great potential [illegible] effectiveness [illegible] reducing contamination of nontarget organisms.

On July 15 approximately 2,3[illegible] acres were sprayed [illegible] new techniques of atmospheric transport and diffusion [illegible] tions in the area were reduced an average of [illegible] area. Surveillance of both [illegible] adverse effects due to spraying.

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In terms of cost per acre this was perhaps one of the most expensive [illegible] spray projects ever undertaken. In terms of objectives and [illegible] more was attempted on this project than ever before. [illegible] advancements in spray equipment development, atmospheric transport and diffusion techniques, and spray deposit assessment were made. [illegible] that these advancements could be applied on future [illegible] projects. The 1967 Big Smoky Spruce Budworm Project was [illegible] in the search for a substitute for DDT [illegible]

APPENDIX

A. Information and Education Lists.

1. Contacts

Various individuals were to be contacted at different times between February and June. Following is a list of individuals and groups that were contacted:

Governor of Idaho
Idaho Congressional Delegation
Forest Supervisors and ARF's
Director, Idaho Fish and Game Department
Chairman, Idaho Fish and Game Commission
Sawtooth National Forest Personnel
Intermountain Pest Action Council
FAA (Idaho)
Idaho State Aeronautics Director
State Public Health Service Officials
Idaho State Forester
Local Idaho Legislators
Supervisor's Advisory Board
Gooding and Fairfield City Mayors
National Wildlife Federation, Western Representative
National Wildlife Federation, Idaho Director
Idaho Wildlife Federation, President
Idaho Wildlife Federation, Vice President
Wilderness Society
University of Idaho, Dean-Forestry School
Idaho Fish and Game Department, Local Officials
Bureau of Land Management, Local Officials
USDA, Local Officials
Livestock Permittees
Wendell Mill and Lumber Co.
Local Civic Organizations
Local Chambers of Commerce
Local Wildlife and Sport Clubs and Associations

2. News Media

A general news release was given to the following media:

Ogden and Salt Lake Press
Twin Falls Press (Appendix #1), radio, and TV
Boise Press
Gooding and Fairfield Press

During the project the following newspapers did feature stories:

Twin Falls, Times-News (Appendix #2)
Boise, The Idaho Daily Statesman (Appendix #3)
Salt Lake Tribune (Appendix #4)
Gooding newspaper

The Times-News story was an Associated Press Special Report and distributed throughout the Western States.

The local TV station, KMVT, prepared a 30-minute video tape program on the project. Dr. Art Moore and Timber Staff Officer Phil Cloward were interviewed on the program. The Zectran film developed by PSW was shown in color and narrated by Dr. Moore.

3. "Show-Me" Trips

Various groups that were given conducted tours included:

Regional Forester's trip including Regional Office personnel, State officials, and members of the news media.

Magic Valley ASCS county supervisors.

Camas County 4-H Club.

4. Information Materials

The following information materials were prepared and distributed:

Brochure on spruce budworm prepared by the Regional Office.

Zectran Fact Sheet prepared by Pacific Southwest Forest and Range Experiment Station.

Big Smoky Fact Sheet prepared by the Sawtooth National Forest.

5. Special Visitors

A partial list of visitors to the project can be found on page 44.

NAME	TITLE OR JOB	AGENCY	LOCATION
P. M. Rees	Supervisor	U. S. Forest Service, Sawtooth National Forest	Twin Falls, Idaho
James Martin	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
Edward Elliott	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
Robert Glenn	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
Dr. James L. Taylor	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
Michael J. Mayzone	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
John Noh	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
Marshall Everheart	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
Everett Coates	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
O. J. Smith	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area
Frederick R. Baugh	Branch Chief	U. S. Forest Service, Sawtooth National Forest	Twin Falls, Idaho
Art Matilla	Engineer	U. S. Forest Service, Missoula Equip. Dev. Center	Missoula, Montana
Malcome Greany	Engineer	U. S. Forest Service, Missoula Equip. Dev. Center	Missoula, Montana
Ed Godbout	Engineer	U. S. Forest Service, Missoula Equip. Dev. Center	Missoula, Montana
Warren Benedict	Retired (former WO Div. of Pest. Control, Director)	U. S. Forest Service	Washington, D. C.
Dr. R. E. Stevens	Forest Insect Research	U. S. Forest Service	Washington, D. C.
Jack Bongberg	Director of Div. of Pest Control	U. S. Forest Service	Washington, D. C.
Al Rivas	Branch Chief, Insect and Disease Control	U. S. Forest Service, R-4	Ogden, Utah
Monte Pierce	Air Operations	U. S. Forest Service	Washington, D. C.
Galen Trostle	Insect Control Section Head	U. S. Forest Service, R-4	Ogden, Utah
Louise Parker	Editor and Information Officer	U. S. Forest Service, PSW Forest & Range Exp. Sta.	Berkeley, California
Larry Burton	Information Officer & Photographer	U. S. Forest Service, PSW Forest & Range Exp. Sta.	Berkeley, California
Floyd Iverson	Regional Forester	U. S. Forest Service, R-4	Ogden, Utah
G. L. Watts	Deputy Regional Forester	U. S. Forest Service, R-4	Ogden, Utah
James M. Usher	Asst. Reg. Forester, Engineering	U. S. Forest Service, R-4	Ogden, Utah
Marlin C. Galbraith	Asst. Reg. Forester, Timber Management	U. S. Forest Service, R-4	Ogden, Utah
H. S. Coons	Asst. Reg. Forester, Fire Cont. & State & Pri. For.	U. S. Forest Service, R-4	Ogden, Utah
E. C. Crary	Asst. Reg. Forester, Fiscal Control	U. S. Forest Service, R-4	Ogden, Utah
A. E. Smith	Asst. Reg. Forester, Information and Education	U. S. Forest Service, R-4	Ogden, Utah
R. E. Carey	Asst. Reg. Forester, Operation	U. S. Forest Service, R-4	Ogden, Utah
N. B. Opsal	Asst. Reg. Forester, Personnel Management	U. S. Forest Service, R-4	Ogden, Utah
F. C. Curtiss	Asst. Reg. Forester, Range Management	U. S. Forest Service, R-4	Ogden, Utah
J. M. Herbert	Asst. Reg. Forester, Recreation and Lands	U. S. Forest Service, R-4	Ogden, Utah
D. M. Gaufin	Asst. Reg. Forester, Wildlife Management	U. S. Forest Service, R-4	Ogden, Utah
S. L. Cuskelly	Asst. Reg. Forester, Soil & Water Management	U. S. Forest Service, R-4	Ogden, Utah
Silas Tolushe	Nigerian Forester	Student	Nigeria, Africa
Merle Markeley		Bureau of Sports Fisheries and Wildlife	Washington, D. C.
Mark Morton	Fishery Biologist, Fishery Services Div.	Bureau of Sports Fisheries and Wildlife	Portland, Oregon
David Lenhart	Fishery Biologist, Fishery Services Div.	Bureau of Sports Fisheries and Wildlife	Portland, Oregon
Cal Royall	Fishery Biologist, Fishery Services Div.	Bureau of Sports Fisheries and Wildlife	Portland, Oregon
Loveless	Denver Wildlife Research Center	Bureau of Sports Fisheries and Wildlife	Denver, Colorado
Oldenmeyer	Denver Wildlife Research Center	Bureau of Sports Fisheries and Wildlife	Denver, Colorado
Godwin Royal	Denver Wildlife Research Center	Bureau of Sports Fisheries and Wildlife	Denver, Colorado
Dr. William M. Upholt	Executive Secretary	Federal Committee on Pest Control	Washington, D. C.
Dr. William S. Murray	Surveys and Investigations Staff	House Appropriations Committee	Washington, D. C.
Melford Fletcher	Plant Pest Control Division	Agricultural Research Service	Twin Falls, Idaho
Lon Stoddard	Plant Pest Control Division	Agricultural Research Service	Twin Falls, Idaho
Keith Evans	Plant Pest Control Division	Agricultural Research Service	Twin Falls, Idaho
Dr. James J. Fettes	Director, Chemical Control Research Institute	Canadian Department of Forestry	Ottowa, Canada
Mr. A. P. Randall	Chemical Control Research Institute	Canadian Department of Forestry	Ottowa, Canada
Mr. Lindsey		Canadian Defense Department	Ottowa, Canada
Dorothy Povey	Free Lance Writer		Hailey, Idaho
Harold Lambright	Technical Representative	Dow Chemical Company	San Francisco, Calif.
Frank B. Livaudais	Franchise for Chemical Fog Method		Luling, Louisiana
Dr. Elmo Shipp	Technical Representative	Chemagro	Kansas City, Kansas
Gene Kenaga	Environmental Influences	Dow Chemical Company	Midland, Michigan
Ralph Hall	Consulting Entomologist		Orinda, California
P. F. Engelking	State Supt. of Public Instruction	Idaho State Dept. of Education	Boise, Idaho
E. Wohletz	Dean, College of Forestry	University of Idaho	Moscow, Idaho
Joe Williams	State Auditor	Department of Public Lands	Boise, Idaho
Jack Gillette	Assistant Land Commissioner, Forestry & Fire	Idaho Department of Public Lands	Boise, Idaho
Ted Hoff	President	Southern Idaho Forestry Association	Boise, Idaho
Joe Pechanec	Director, INT Forest & Range Exp. Sta.	U. S. Forest Service	Ogden, Utah
Vern Guernsey	Vice President	Boise Cascade Corporation	Boise, Idaho
Bob Hayes	Secretary	Southern Idaho Forestry Association	Boise, Idaho
Bob Lorimer	Newspaper Writer	Idaho Daily Statesman	Boise, Idaho
Wilhelm Beckert	Director	Idaho Parks Department	Boise, Idaho
Fred Humphreys	Vice President and Cashier	Idaho First National Bank	Boise, Idaho
Joel Frykman	Consulting Forester		Ogden, Utah
Jim Simpson	Chief, Fisheries	Fish and Game Department	Boise, Idaho
Art Roberts	Forest Counsel	Western Forestry & Conservation Assn.	Portland, Oregon
David Mead	Board Member	Sawtooth National Forest Advisory Committee	Magic Valley Area

B. Weather in Project Area

Following are precipitation and thunderstorm activity at Shake Creek and Fairfield Ranger Stations during the period of June 5 to July 17. No records were kept for the project area but project area weather activity was similar to that experienced at Fairfield. In addition, heavy fog was experienced on the project area almost every morning during the period. The fog usually lasted until 10 or 11 a.m. and sometimes did not lift until noon.

	Fairfield Ranger Station		Shake Creek Ranger Station	
Date	Precipitation	Weather	Precipitation	Weather
6/5/67	.27	T.S.*	.13	T.S.
6/6/67	.42		.54	
6/7/67	.15	Fog, T.S., Hail		
6/8/67	.23	T.S.	.07	
6/9/67	.30	T.S.	.02	
6/10/67	Trace		Trace	
6/11/67			.11	
6/13/67	.11		.05	
6/14/67	.05			
6/15/67	.05	Fog	.01	
6/16/67	.40			
6/17/67	Trace		.32	T.S.
6/20/67	.04	T.S.		
6/21/67	.60	T.S.	.67	
6/22/67	.35	T.S., Hail	.11	Fog, Stratus
6/23/67	.01		.06	Cloudy
6/24/67	.08			Fog
6/25/67			.02	Fog, Low Stratus
6/27/67	.04		.24	
6/28/67			.12	
7/4/67	.09	T.S.	.04	T.S.
7/7/67	.02		.04	T.S.
7/17/67	.30		.56	

* T.S. indicates thunderstorm

C. Project Aircraft Use

	Cost/hr.	No. of hrs. used	Total cost
Smoke plane observation Cessna 205 Sun Valley Airlines, Gooding, Idaho	$ 35/hr.	49.2	$2,000
Fixed wing single-engine spray plane Grumman TBM Reeder Flying Service, Twin Falls, Idaho	340/hr.	15.3	5,500
Rotor spray plane Bell 4763B Mountain West Helicopters, Provo, Utah	120/hr.	22.5	2,800
Rotor observation and temperature probing Bell 4763B Helicopters Inc., Boise, Idaho	123/hr.	37.0	7,400
Fixed wing multi-engine spray plane C-47 (DC-3) Forest Service, Region 4	150/hr. or at least 300/day	8.5 Stand by 26.5	1,400 4,000
Fixed wing single-engine spray plane Cessna 185 Forest Service, Region 1	22/hr.	Breakdown	
Fall survey helicopter	$128/hr.	7.0	900

D.

1967 BIG SMOKY SPRUCE BUDWORM PROJECT COSTS

	OVERHEAD ASSESSMENT	GENERAL OPERATIONS		ENTOMOLOGISTS		SURVEILLANCE		CAMP CONSTRUCTION	SUBSISTENCE & CAMP MAINT.		TOTALS	
DIRECT PROJECT COSTS (Sawtooth N.F. Allot.)												
Salaries		4,048 hrs.	$8,250	5,155 hrs.	$10,250	779 hrs	$2,800		1,785 hrs	$5,800		$ 27,100
Per Diem			1,600		600		200			400		2,800
Meals and Kitchen										5,500		5,500
Vehicle Rental		29,937 mi.	3,600	13,985 mi.	2,000	10,300 mi.	1,100		10,040 mi.	1,500	(64,262 mi.)	8,200
Miscellaneous Supplies			500		160		40			120		820
Telephone			160		80		40			60		340
Radio			1,050									1,050
Maps, Aerial Photos, Etc.			700									700
I&E Supplies			500									500
Aerial Operations												
Airport Expenses			50									
Administrative Flying		22 hrs.	1,100	3 hrs.	400							
Spraying (Helicopter)		22.5 hrs.	2,800									
Spraying (Single Eng. Fixed Wing) TBM		15.3 hrs	5,500									
Spraying (Multi. Eng. Fixed Wing) C-47		8.5 hrs.	1,400									25,550
Stand By Charge (C-47 2 hrs/day)		26.5 hrs.	4,000									
Observation and Weather (Helicopter)		37.0 hrs.	7,400									
Fall Survey (Helicopter)		7 hrs.	900									
Observation and Smoke Runs (Small Fixed Wing)		49.2 hrs.	2,000									
Insecticide, Freeon, Carrier, etc.			40,600									40,600
Lidar Contract			21,400									21,400
U. S. Weather Bureau (Paid By Sawtooth)			(1,100)	Included in breakdown above								
Camp Construction - Project Funds								11,400				11,400
Camp Construction - "19" Allot.								4,400				4,400
Sawtooth Over Head Assessment	$ 14,800											14,800
SUB-TOTALS	14,800		103,510		13,490		4,180	15,800		13,380		165,160
INDIRECT PROJECT COSTS (CONTRIBUTED)												
Sawtooth N.F. & Regional Office P&M Camp Contribution								9,000				9,000
Regional Office Over Head Assessment	6,000											6,000
Regional Office Base Salaries			9,150		3,650							12,800
R-4 Pilot Salaries			2,000									2,000
Sawtooth N.F. Base Salaries			2,000									2,000
SUB-TOTALS	6,000		13,150		3,650			9,000				31,800
OTHER AGENCY PROJECT COSTS												
U. S. Weather Bureau (Meterologist Salaries)			2,000									2,000
Idaho Fish and Game (Aquatic Surv. - Salaries, Etc.)							500					500
Bur. Sports, Fish, and Wildlife (Terrestrial Sur.)							10,000					10,000
PSWF & R Experiment Station (Insecticide Eval. Project)			12,600		8,000							20,600
Missoula Equipment Develoement Center (Aircraft Spray Systems)			56,800									56,800
SUB-TOTALS			71,400		8,000		10,500					89,900
TOTALS	20,800		188,060		25,140		14,680	24,800		13,380		286,860

E. Summary of Recommendations

1. Assistant project leader should be a full-time position.

2. The information officer should be a full-time position. If it is, no assistant (part-time) information officer will be needed.

3. The size of the entomological crew should be critically analyzed. Apparently the crew size can be smaller and still do a satisfactory sampling job.

4. The entomological lab should be located as close to the field headquarters as practical.

5. Create a spray strategist position and fill it with the most knowledgeable and experienced man available.

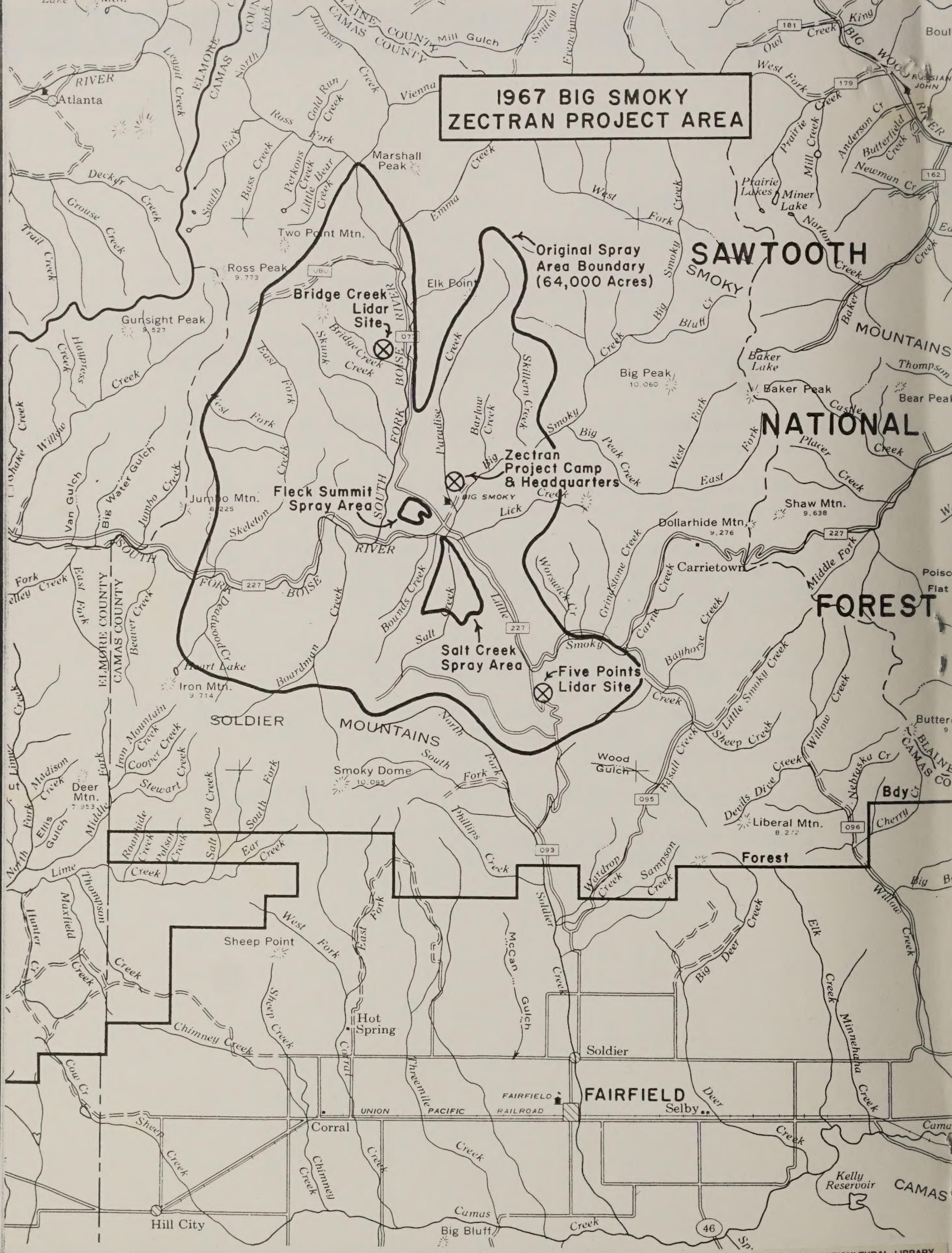
6. An administrative assistant should be involved in the project from the early planning stages to the final analysis of cost data. He should be able to devote full time to the project as necessary on a first priority basis.

7. Automatic telephone patches should be used wherever possible to link the radio and telephone systems together.

8. Transistorized portable radios on the aircraft frequencies should be used to control aircraft from field locations and in air search and rescue operations in case of crashes.

9. Use modern radios of adequate power for ground communications.

10. Consider using two meteorologists on a shift basis rather than one man working as much as 19 to 20 hours each day.


1967 BIG SMOKY
ZECTRAN PROJECT AREA
Original Spray
Area Boundary
(64,000 Acres)
Bridge Creek
Lidar
Site
Zectran
Project Camp
& Headquarters
Fleck Summit
Spray Area
Salt Creek
Spray Area
Five Points
Lidar Site
SAWTOOTH
NATIONAL
FOREST
SMOKY
MOUNTAINS
SOLDIER
MOUNTAINS
BLAINE COUNTY
CAMAS COUNTY
ELMORE COUNTY
CAMAS COUNTY
Atlanta
Marshall
Peak
Two Point Mtn.
Ross Peak
9,773
Gunsight Peak
9,527
Elk Point
Big Peak
10,060
Baker Peak
Bear Peak
Baker
Lake
Prairie
Lakes
Miner
Lake
Jumbo Mtn.
8,225
Iron Mtn.
9,714
Heart Lake
Shaw Mtn.
9,638
Dollarhide Mtn.
9,276
Carrietown
BIG SMOKY
Smoky Dome
10,095
Deer
Mtn.
7,953
Liberal Mtn.
8,272
Sheep Point
Hot
Spring
Soldier
FAIRFIELD
FAIRFIELD
Selby
Corral
Hill City
Big Bluff
Kelly
Reservoir
CAMAS
UNION PACIFIC RAILROAD
SOUTH FORK BOISE RIVER
Forest
Bdy
RUSSIAN
JOHN
BIG WOOD RIVER
Wood
Gulch